Journal and Proceedings of the Royal Society of New South

VOLUME 117 · 1983
(Nos. 3[illegible])

Published by the Society
P.O. Box N112, Grosvenor
Issued January
ISSN 0035-

THE ROYAL SOCIETY OF NEW SOUTH WALES

Address:— Royal Society of New South Wales,
PO Box N112 Grosvenor Street,
NSW 2000,
Australia.

THE ROYAL SOCIETY OF NEW SOUTH WALES

The Society originated in the year 1821 as the Philosophical Society of Australasia. Its main function is the promotion of Science through the following activities: Publication of results of scientific investigation through its Journal and Proceedings; the Library; awards of Prizes and Medals; liaison with other Scientific Societies; Monthly Meetings; and Summer Schools for Senior Secondary School Students. Special Meetings are held for the Pollock Memorial Lecture in Physics and Mathematics, the Liversidge Research Lecture in Chemistry, and the Clarke Memorial Lecture in Geology.

Membership is open to any interested person whose application is acceptable to the Society. The application must be supported by two members of the Society, to one of whom the applicant must be personnally known. Membership categories are: Ordinary Members, Absentee Members and Associate Members. Annual Membership fee may be ascertained from the Society's Office.

Subscriptions to the Journal are welcomed. The current subscription rate may be ascertained from the Society's Office.

The Society welcomes manuscripts of research (and occasional review articles) in all branches of science, art, literature and philosophy, for publication in the Journal and Proceedings.

Manuscripts will be accepted from both members and non-members, though those from the latter should be communicated through a member. A copy of the Guide to Authors is obtainable on request and manuscripts may be addressed to the Honorary Secretary (Editorial) at the above address.

ISSN 0035-9173

Journal and Proceedings, Royal Society of New South Wales, Vol. 117, pp. 85-97, 1984
ISSN 0035-9173/84/020085 — 13 $4.00/1

Interpretation of Macroscopic Fold Structures in the Willyama Supergroup of the Thackaringa Area, Broken Hill, N.S.W.

I. L. WILLIS

ABSTRACT. The present complex distribution of lithological and stratigraphic units in the Thackaringa area is due mainly to the formation of macroscopic interference structures during multiple deformation. Three main generations of superimposed macroscopic folds are recognized in the area: F_1, F_2, F_3, with axial plane schistosities S_1, S_2, S_3. These correspond with identical D_1, D_2 and D_3 structures recognized by others elsewhere in the Broken Hill Block, indicating that there are no substantial differences in structural evolution between the south-west, and the north and central, Broken Hill Block. A fourth generation (F_4) macroscopic fold may represent a localized structural event in the study area.

The lobate and dome-and-basin macroscopic interference pattern in the south Thackaringa district is interpreted to have formed mainly by interaction of F_1/F_2 and F_2/F_3 folds. This open interference pattern, with easterly-trending F_2 fold axial plane traces, is unusual within the Broken Hill Block. It is speculated that these easterly trends may have been to some extent controlled or influenced by the adjacent Thackaringa-Pinnacles Schist Zone.

INTRODUCTION

In recent detailed structural studies in the Broken Hill region, the general framework of deformation generations, and the distribution of many major fold structures, have been largely established for some parts of the Broken Hill Block (e.g. Hobbs 1966, Williams 1967, Rutland and Etheridge 1975, Archibald 1978, Marjoribanks *et al* 1980). The majority of these studies were detailed structural analyses, concentrated in the northern and central areas of the Broken Hill Block, especially in the vicinity of the Broken Hill mines, where structural elements are particularly well developed in the dominantly pelitic metasediments of the middle and upper sections of the Broken Hill sequence (the Broken Hill and Sundown Groups of Willis *et al* 1983).

In the most recent of these studies, three generations of major folds have been recognized (F_1, F_2, F_3 - see Table 1), with F_1 and F_2 folds having had the major impact as regional-scale structures (e.g. Majoribanks *et al* 1980). Throughout most of the Broken Hill Block, the dominant structural grain imparted by these major folds, particularly isoclinal F_2 structures and major shears, is northeast-southwest. Although "arrowhead" and "dome-and-basin" type macroscopic interference patterns are present, there are relatively few domains of open interference structures (see Archibald 1978 for discussion).

In this paper, macroscopic folds in the Thackaringa area (Fig 1) are described and interpreted, as a complementary study to the published structural descriptions. The Thackaringa area is of some significance in this context because :

(1) It has excellent exposure of traceable lithological and stratigraphic units which can be used to interpret and accurately define fold form surfaces (Fig 2) (Willis 1980*b*, 1982a,b).

(2) It has an unusually (for the Broken Hill Block) open set of complex macroscopic fold interference structures, dominated particularly by east-west, as opposed to the more typical northeast, major trends of structure and stratigraphy.

(3) The area mainly comprises quartzo-feldspathic lithologies from the lower-middle sections of the Broken Hill Block stratigraphy (Thackaringa Group of Willis *et al* 1983), permitting comparison of structural elements with those already described in detail from the more pelitic lithologies higher in the sequence elsewhere in the Broken Hill Block.

(4) The Thackaringa area provides a suitable area for comparison of structural elements and fold generations from the southwestern Broken Hill Block with those from the more intensively studied northern and central areas.

In addition this paper further amplifies a different approach to interpretation of macroscopic structures in the Broken Hill Block, as employed by Archibald (1978), Stevens *et al* (1980), and Willis *et al* (1983). This approach relies more heavily on interpretation of form surfaces defined by lithological and stratigraphic markers, than on extrapolation of mesoscopic data from detailed structural analyses (see below).

GENERAL GEOLOGY

The Thackaringa area comprises mainly granulite facies metasediments, composite gneisses, quartzo-feldspathic gneisses, leucocratic quartzo-feldspathic rocks, and basic gneisses of the Early Proterozoic Willyama Supergroup (see Willis 1980*a* for full descriptions). The exposures are mainly from the middle sections of the stratigraphic sequence, principally the Thackaringa and Broken Hill Groups of Willis *et al* (1983), Stevens *et al* (1983) (Table 2).

The most prominent planar structural features in the area (Fig 3) are the Mundi Mundi Fault, separating the Thackaringa area from the Mundi Mundi Plain, and the Thackaringa - Pinnacles Schist Zone (T-P SZ). The T-P SZ is an east-west zone of ductile deformation and retrograde metamorphism which truncates the general northeast -southwest structural trends of the Broken Hill Block.

The history of deformation in the Thackaringa area involves the three main penetrative deformational events recognized in recent studies elsewhere in the Broken Hill Block (Table 1), with schistosities S_1, S_2, S_3, and F_2, F_3 and inferred F_1 folds present. A fourth non-penetrative deformation (F_4, S_4) has also been recognized in the south Thackaringa district. The deformations are recognized at meso- and macroscopic scale by overprinting criteria (Figs. 3,4).

APPROACH OF THIS STUDY

With excellent exposure of structural and stratigraphic markers, a standard detailed structural analysis was not necessary for the delineation of most of the major macroscopic folds in the Thackaringa area. Instead, the macroscopic fold form surfaces were outlined by detailed mapping of the marker units, and in some cases by recognizing fold axial plane traces on the basis of reversals of the interpreted stratigraphy (*c.f.* Stevens 1980, Willis *et al* 1983). The different generations of folds were interpreted from the overprinting relationships of small-scale structural elements in key areas. The attitudes of bedding and schistosity in hinge areas, and the vergence of minor folds and bedding/schistosity relations, were used in some areas. This is very similar to the regional structural interpretation technique used by Archibald (1978) in the northern and central Broken Hill Block. This approach provides a suitable first-pass regional structural interpretation, which can be more rigorously tested by detailed structural analysis in key areas at a later date. In the south Thackaringa area, F. Funnell (*pers. comm.* 1983) is currently undertaking such an analysis of some of the structures outlined by Willis (1980*a*) and Stroud (*in prep.*).

Without a detailed structural analysis, it was initially assumed that the chronology and styles of fold generations established elsewhere in the Broken Hill Block (e.g. Marjoribanks *et al* 1980) were also present in the Thackaringa area; this was subsequently largely validated.

STRUCTURAL AND STRATIGRAPHIC MARKERS

The area was mapped at 1:12,000 scale, outlining a wide variety of rock units that could be used as structural and stratigraphic markers (Willis 1980*a*, *b*). The most useful and distinctive of these, a thin quartzo-feldspathic leucogneiss from Cues Formation, has exceptional continuity throughout the Thackaringa area and was the major datum used in interpretation of the macrostructure in the lithologically complex Thackaringa Group rocks (see Willis 1982a for description and details of the leucogneiss). The upper boundary of the Thackaringa Group, marked by transition from sodic plagioclase+quartz rocks or quartzo-feldspathic ("granite") gneiss, to metasediments and other rocks of the Broken Hill Group, is also a distinctive and widespread datum. The extensive and continuous bodies of amphibolite, usually with quartz+feldspar+biotite+garnet gneiss, that occur in the Broken Hill Group, can also be traced with a high degree of confidence throughout the area, even within the T-P SZ. The Ettlewood Calc-Silicate Member also provides structural and stratigraphic control in the T-P SZ (Fig. 2). The distribution of stratigraphic units is shown in Fig. 2, and in generalized sections in Fig. 5.

SMALL-SCALE STRUCTURES

Lithological Layering

Throughout the Thackaringa area, as elsewhere in the Broken Hill Block, the earliest recognizable s-surface is a lithological layering which is interpreted as bedding (S_0) (Fig. 4). Outside of the retrograde schist zones, there is no evidence of widespread transposition of S_0 (e.g. rootless fold hinges, extreme limb attenuation, dislocation of layering parallel to schistosity). The layering is also unlikely to be of metamorphic origin, since the layers contain rare sedimentary structures, show internal compositional variation, and are continuous and in sequence as would be expected of a bedded succession. In addition, it is likely that S_0 predates S_1, as has been observed elsewhere in the Broken Hill Block (e.g. Rutland and Etheridge 1975) although the ubiquitous parallelism of S_1 and S_0 precludes verification of their overprinting relationship in the Thackaringa area.

Bedding is best preserved in the leucocratic sodic plagioclase+quartz rocks, in which it is thin (10-200mm), planar, continuous and regular. Bedding of similar geometry is preserved as psammite layers in metasediments of the Broken Hill and Sundown Groups. In the metasedimentary composite gneisses of the Thackaringa Group and Thorndale Composite Gneiss, S_0 tends to be thin, lenticular to planar, and discontinuous. Apart from bedding, sedimentary structures are very rare in the metasedimentary compositions, but scour-and-fill structures, crossbedding, and compositional grading occur in the well-bedded sodic plagioclase+quartz rocks (Willis 1980*a*, Brown *et al* 1983). The bedding in all the rock units is defined by compositional variation, with rare grainsize variation in some sodic plagioclase +quartz rocks.

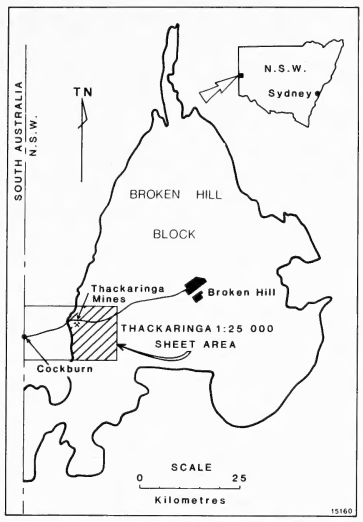


FIG. 1. Location of the study area (shaded). The limits of Willyama Supergroup outcrop are also shown.

TABLE 1

Structural elements observed in the Thackaringa sheet area (Willis 1980*a*) compared with those from elsewhere in the Broken Hill Block (Rutland and Etheridge 1975, Laing *et al*, 1978, Marjoribanks *et al* 1980).

	BROKEN HILL BLOCK		NORTH THACKARINGA AREA		SOUTH THACKARINGA AREA
S_0	Bedding	S_0	Bedding	S_0	Bedding
D_1		D_1		D_1	
F_1	Large-scale isoclines (nappes?)	F_1	Not observed	F_1	Large-scale isocline
S_1	High-grade schistosity/ gneissosity, usually parallel to bedding	S_1	High-grade schistosity/ gneissosity, usually parallel to bedding	S_1	High-grade schistosity/ gneissosity, always parallel to bedding
L_1	Mineral lineation				
D_2		D_2		D_2	
F_2	Tight to isoclinal, meso- to macroscopic folds	F_2	Tight to isoclinal, meso- to macroscopic folds; minor folds common	F_2	Tight to isoclinal, meso- to macroscopic folds; minor folds common
S_2	High-grade schistosity	S_2	High-grade schistosity	S_2	High-grade schistosity
L_2	Mineral lineation	L_2	Mineral lineation	L_2	Mineral lineation
D_3		D_3		D_3	
F_3	Open to tight, meso- to macroscopic folds	F_3	Open to moderately tight, meso- to macroscopic folds	F_3	Open to moderately tight, meso- to macroscopic folds
S_3	Variable-grade schistosity usually retrograde	S_3	Upright, retrograde schistosity; some schist zones axial planar to F_3	S_3	Retrograde schistosity
L_3	Mineral lineation	L_3	Mineral lineation	L_3	Mineral lineation
	Not observed		Not observed	D_4	
				F_4	Macroscopic open fold
				S_4	Non-penetrative retrograde schistosity or defined by small schist zones

TABLE 2

Stratigraphy of the Thackaringa area, after Willis (1980a) and Willis *et al* (1983).

GROUP	FORMATION	LITHOLOGY
SUNDOWN GROUP S		Interbedded pelitic to psammopelitic metasediment with some psammite; minor psammitic to psammopelitic composite gneiss; common zoned calc-silicate nodules
BROKEN HILL GROUP B		Garnet-rich psammitic to psammopelitic metasediment interbedded with quartz+feldspar+biotite+garnet gneiss, garnet- and/or pyroxene-rich amphibolite, fine-grained garnet+quartz rocks and minor quartz+ gahnite rock; common zoned calc-silicate nodules
Purnamoota Subgroup BS	HORES GNEISS Bh	Medium- to fine-grained quartz+feldspar+biotite+ garnet gneiss, with evenly distributed, rounded garnets; equigranular, poorly gneissic; inferred lateral transition to granular quartz+gahnite rock
	FREYERS METASEDIMENTS Bf	Psammitic to psammopelitic metasediments
	PARNELL FORMATION Bp	Medium- to coarse-grained garnet- and/or pyroxene-bearing amphibolite; quartz+feldspar+biotite+ garnet garnet gneiss; garnet+quartz rock, quartz+gahnite rock
	ALLENDALE METASEDIMENTS Ba	Garnet- rich psammopelitic and/or psammitic metasediments, with minor amphibolite
	Ettlewood Calc-silicate Member Be	Layered calc-silicate rock (Ettlewood type)
THACKARINGA GROUP T	HIMALAYA FORMATION Th	Bedded sodic plagioclase+quartz (+ pyrite) rocks, minor amphibolite
	RASP RIDGE GNEISS Tr	Quartz+feldspar+biotite ("granite") gneiss, with garnet phases
	CUES FORMATION Tc	Psammopelitic to psammitic metasediments and/or composite gneisses interbedded with quartz+feldspar +garnet leucogneiss; amphibolite; minor quartz+ feldspar+biotite+garnet gneiss; and siliceous quartz+iron oxide rock; also garnet+quartz rock, garnet+epidote calc-silicate rock
	ALDERS TANK FORMATION Tt	Quartzo-feldspathic and metasedimentary composite gneiss
	LADY BRASSEY FORMATION Tl	Bedded sodic plagioclase+quartz rocks, quartzo-feldspathic composite gneiss, interbedded amphibolite
	ALMA GNEISS Ta	Medium-grained megacrystic quartz+feldspar+biotite ("augen") gneiss
	THORNDALE COMPOSITE GNEISS tg	Psammitic metasedimentary composite gneiss and migmatite, with minor amphibolite

First Generation Structures

A high-grade schistosity/gneissosity is commonly visible, defined by alignment of biotite +sillimanite in metasedimentary rocks, by hornblende in basic gneisses, and by biotite in quartzo-feldspathic gneisses. This schistosity is generally S_1, in most cases paralleled by S_2. In some areas the two schistosities can be distinguished; e.g. a strong biotite schistosity (S_1) in quartzo-feldspathic gneiss (Rasp Ridge Gneiss) near Whites Tank is folded by F_2 structures. Northeast of Camels Humps, a biotite schistosity (S_1) in sodic plagioclase+quartz rocks, is deformed by second- and third-generation structures (Fig.4): in general a strong biotite foliation in quartzo-feldspathic gneisses can be equated with S_1.

Wherever it has been observed, S_1 lies parallel to bedding and no small-scale F_1 folds have been located. In most outcrops, S_1 is difficult to distinguish from S_2 since both schistosities are essentially parallel to bedding in the limbs of the F_2 structures which predominate in the area. Where it can be distinguished, S_1 appears to dip to the southeast and northwest throughout most of the area, with some northeast dips recorded where the schistosity is folded about F_2 folds.

Second Generation Structures

Second generation structures deform bedding and S_1, and are themselves deformed by third generation structures (e.g. Fig.4). F_2 folds are tight to isoclinal and occur on all scales. The axial planar schistosity of F_2 folds is S_2. S_2 is defined by biotite and sillimanite in metasediments, and by biotite or quartzo-feldspathic segregations, in quartzo-feldspathic gneisses. In many cases S_2 develops as a strong linear/planar fabric in the hinges of F_2 folds (N.J. Archibald, *pers. comm.* 1978). In quartzo-feldspathic rocks it is variably developed, as a weak foliation (e.g. in the hinge of the Quarry Tank Antiform, Fig. 3), or as a schistosity stronger than S_1 (Fig. 4). In some quartzo-feldspathic rocks S_2 develops as a lamination of quartz and feldspar. A strong mineral lineation plunges parallel to the axes of F_2 folds, and is termed L_2.

F_2 folds plunge steeply to the northeast, parallel to L_2, throughout the area. The schistosity axial planar to these folds, S_2, trends to the northeast or east-northeast in general, with steep dips to the northwest or southeast (Fig. 5).

Third Generation Structures

Throughout the Thackaringa area, bedding (S_0) and the early high-grade schistosities S_1 and S_2 are overprinted by a subvertical north-(rarely northeast-) trending retrograde schistosity S_3. S_3 is axial planar to meso- and macroscopic folds (F_3) which are open to moderately tight in style, with rounded to angular hinges.

S_3 typically occurs as an intense penetrative micaceous schistosity in pelitic compositions, defined by muscovite, biotite and chlorite. It occurs as a weak parting or coarse micaceous foliation in quartzo-feldspathic lithologies (insets A, B in Fig. 4). The schistosity is typically intensely developed in the hinges of F_3 folds, with weak development in the limbs. A strong mineral lineation (L_3) defined by quartz and micaceous minerals is ubiquitous in S_3. This lineation plunges parallel to the axes of small F_3 folds, and appears to be parallel to F_3 axes on a regional scale.

Throughout the area S_3 (and F_3 axial planes and axial plane traces) mainly strike north-south and dip subvertically, although in some areas the schistosity has a more northeasterly trend, with subvertical to northwest dips (Figs 3,4). F_3 axes throughout the area plunge steeply. These plunges are to the south in the Quarry Tank area, in the Paddock Well area, and mainly to the north in the south Thackaringa district.

Fourth Generation Structures

Fourth generation structures are rare and have only been observed in the area northeast of Camels Humps (Figs. 3,4), where a macroscopic east-northeast-trending F_4 fold (and other possible F_4 folds) has been observed. Definite small-scale F_4 folds have not been recorded, although steeply-plunging open to tight minor folds at GR 14984994 (inset C, Fig 4) are interpreted to be of the fourth generation (they may represent F_2 folds reoriented on the limb of an F_3 fold). These minor ?F_4 folds have small-scale axial planar shears and retrograde schistosity (?S_4).

S_4 is apparent in the hinge of the macroscopic F_4 fold as an upright axial planar foliation defined by strong, discrete east-west shears and retrograde micaceous schistosity. S_4 is variably developed and does not appear to be a penetrative foliation.

MACROSCOPIC STRUCTURE

The macroscopic fold interference pattern in the Thackaringa area is shown in Fig. 3, and discussed in detail below. Generalized sections across the area showing interpretation of some of the macroscopic folds are shown in Fig. 5.

First Generation Folds

F_1 closures have not been directly observed in the Thackaringa area, although the high grade schistosity which is interpreted to have formed during D_1 is everywhere apparent. Difficulty in recognizing F_1 folds is a problem throughout the Broken Hill Block, due mainly to imposition of D_2 and D_3 strain effects and the probable restricted hinge areas of the F_1 macroscopic folds (Marjoribanks *et al* 1980). In the Thackaringa area, these problems are compounded by a lack of suitable pelitic/psammopelitic lithologies in which stratigraphic younging criteria and S_1 and S_2 can be consistently distinguished.

Laing *et al* (1978) and Marjoribanks *et al* (1980) have made extensive use of structural facing (Borradaile 1976) on F_2 folds to delineate F_1 fold axial plane traces. By using sedimentary younging directions, almost exclusively from pelite-rich facies of the Sundown and Broken Hill Groups, they outlined domains of upward- and downward-facing F_2 folds in parts of the central Broken Hill Block, delineating F_1 axial plane traces at zones of changing facing (Fig. 9 of Marjoribanks *et al* 1980).

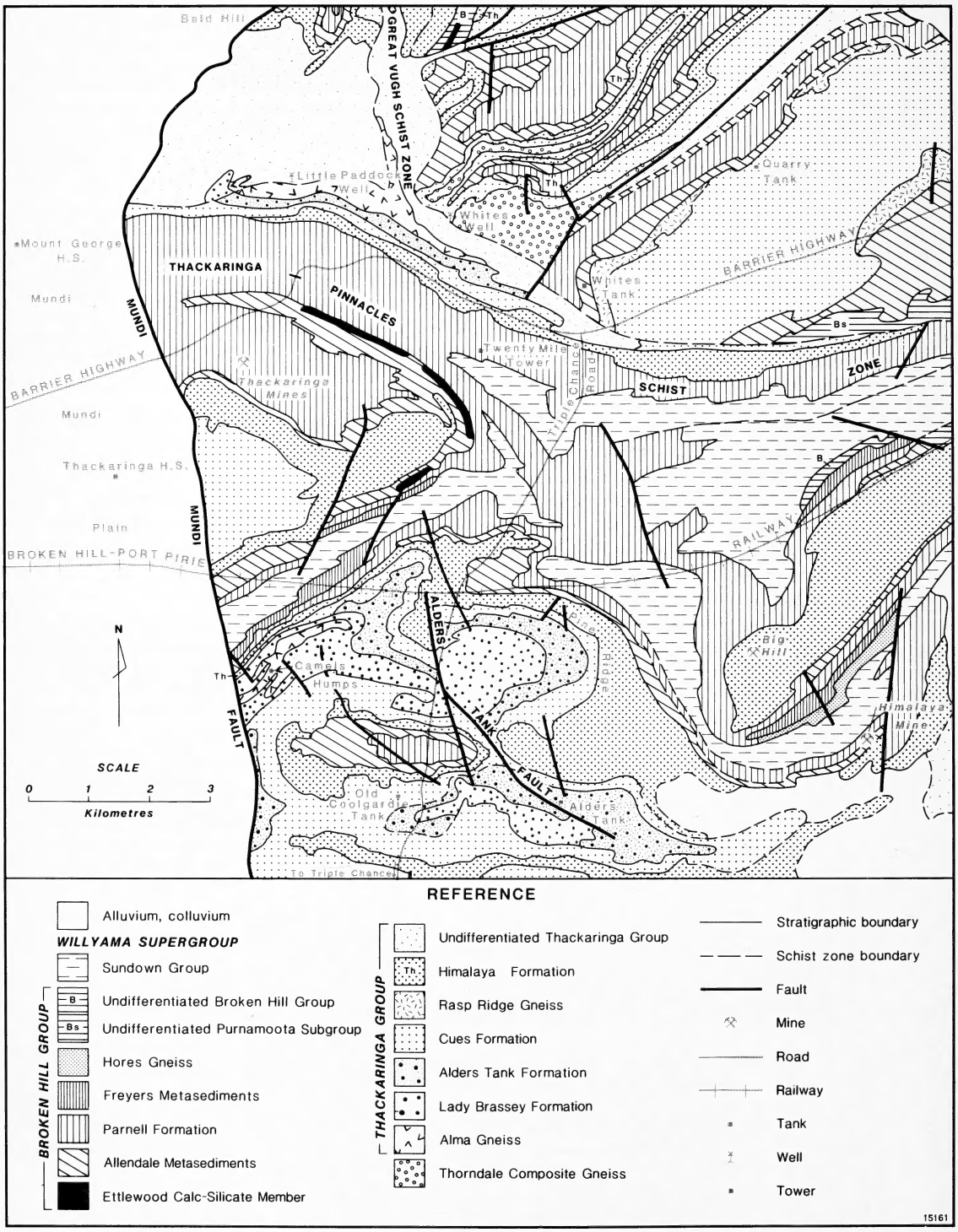


FIG. 2. Stratigraphic interpretation of the Thackaringa area, after Willis 1980a, b, 1982b. For lithological descriptions of units, see Table 1.

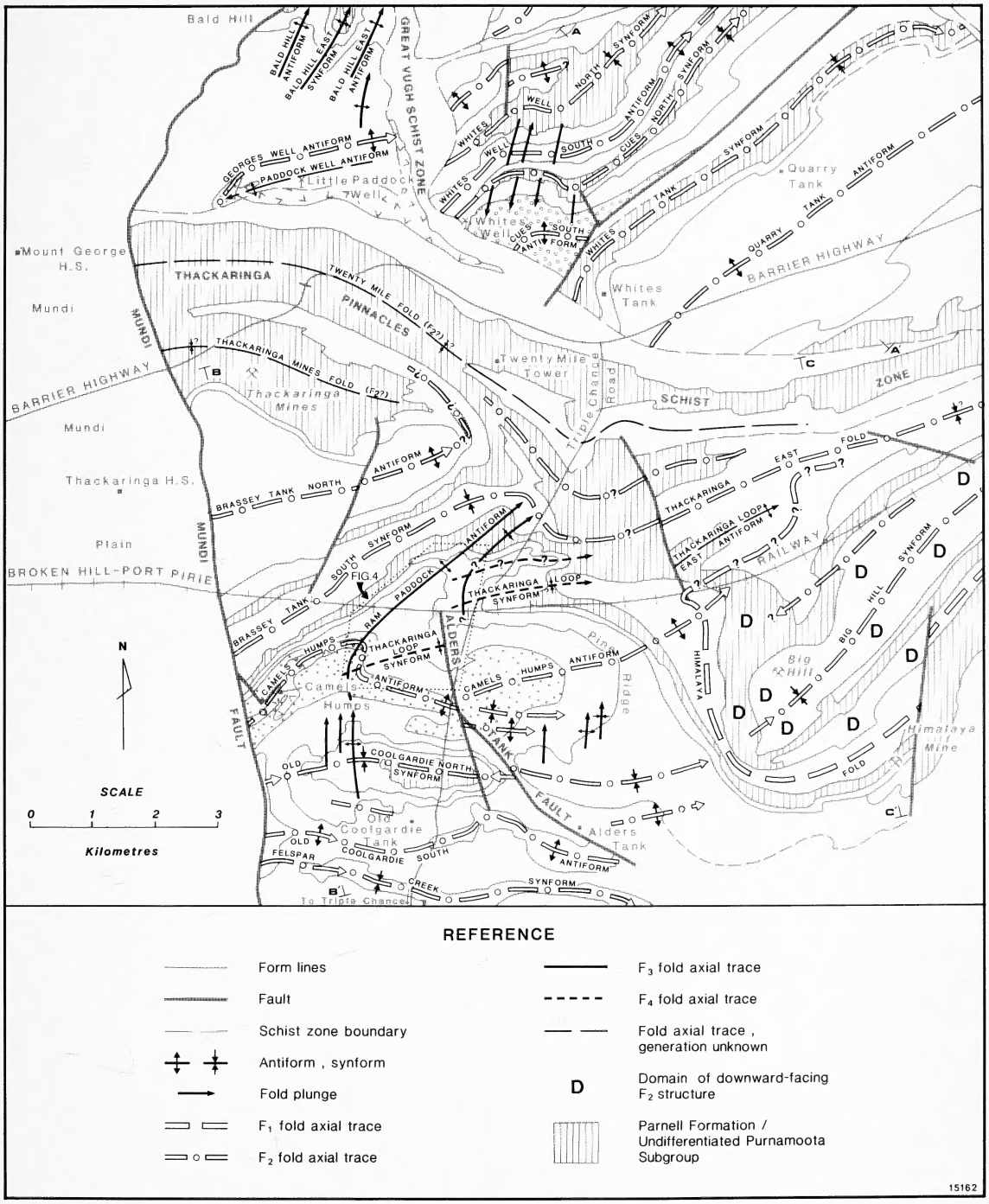


FIG. 3. Distribution of major folds in the Thackaringa area. Note that not all folds or faults are shown or named. Refer to Fig. 2 for additional reference.

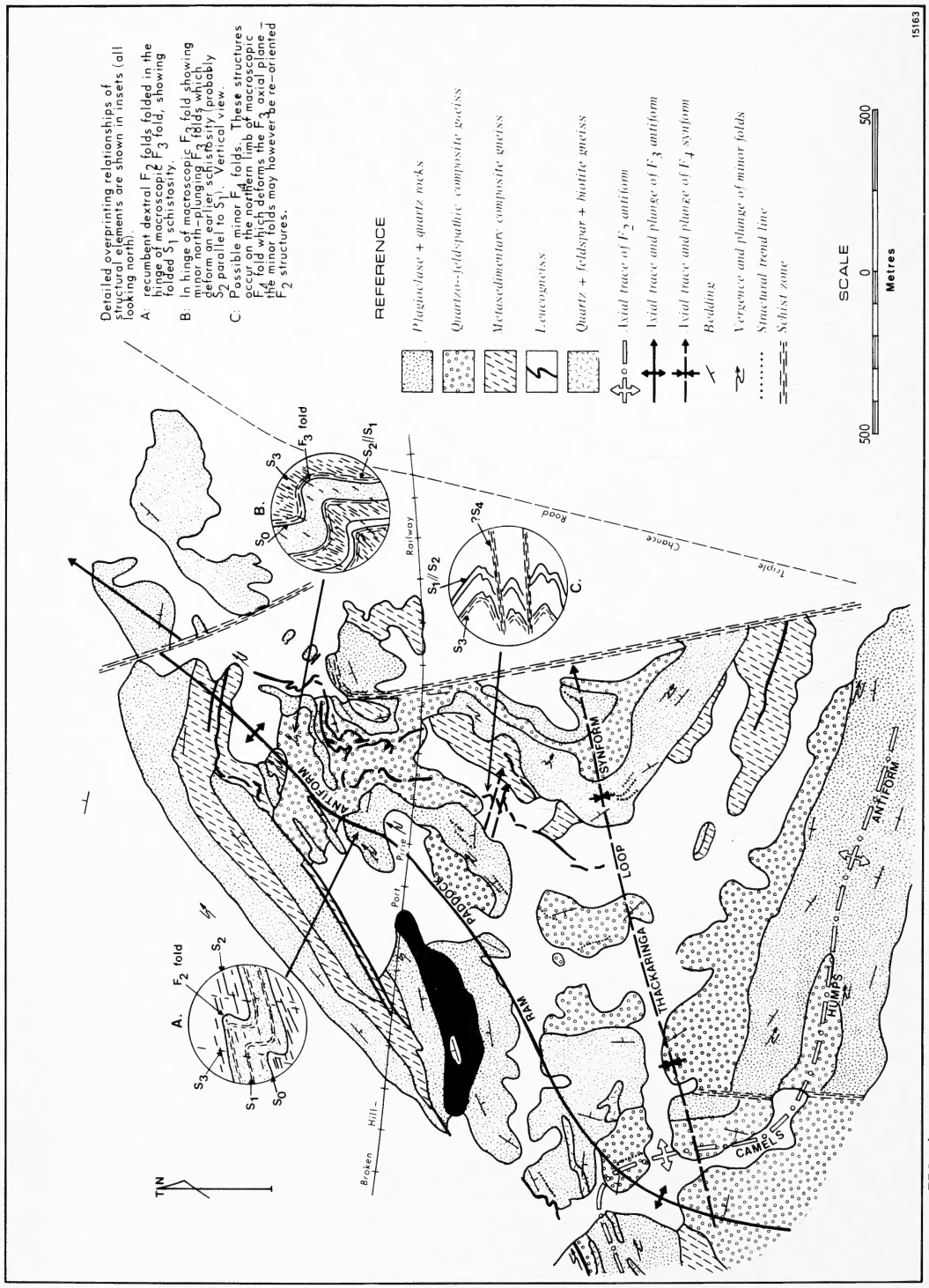


FIG. 4. Structural relationships in a critical area in the south Thackaringa district (location shown in Fig. 3), after Willis (1980b). For simplification, not all lithologies are shown e.g. amphibolite. Note that the generations of minor folds are not distinguished, although most are F_2, F_3 in age. For stratigraphic simplification refer to Willis (1982a, b).

The interpretation of upward and downward-facing domains in the central Broken Hill Block has also been supported by using detailed stratigraphic interpretation of the mapped rock units, rather than structural and sedimentary data (*c.f.* Archibald 1978, Brown 1980, Stevens *et al* 1980, Willis *et al* 1983). Similarly, by using the stratigraphic interpretation of the Thackaringa area outlined by Willis (1980*a*, *b*) it is possible, despite the lack of sedimentary younging data, to infer the younging directions, and hence facings, on F_2 folds in the Thackaringa area. The method relies on confident interpretation of the attitude and generation of the folds concerned, which cannot always be assured. However, south of the T-P SZ, the north-plunging Big Hill Synform can be confidently designated a downward-facing F_2 structure (an inverted F_2 anticline) (Fig. 3). The many regional F_2 folds to the west, from Brassey Tank North Antiform south to the Felspar Creek Synform, are interpreted with mixed degrees of confidence, to be consistently upward facing. The zone of transition from upward to downward-facing domains corresponds with the Himalaya Fold (Fig. 3), which is therefore inferred to be F_1. The Himalaya Fold also corresponds with a younging reversal about which the stratigraphy is symmetrically distributed, and is clearly deformed by the F_2 Big Hill Synform and Camels Humps Antiform, supporting the conclusion that the Himalaya Fold is an F_1 structure.

The Himalaya F_1 fold axial plane trace disappears under alluvium to the east. The northern trace of the fold cannot be confidently traced. The domain of upward-facing F_2 structures from the Brassey Tank North Antiform to the south suggests that these structures lie on the upward-facing limb of the F_1 fold, and that the axial plane trace does not occur in this area. It is more likely that the axial plane trace trends to the north, passing into the area of complex geology and fold interactions on the southern margins of the T-P SZ, in the central part of the study area. It is suggested that the fold would be folded about the east-trending F_2 structures in this area (e.g. Camels Humps Antiform, Thackaringa East Fold), before being either smeared out to the east or west within the T-P SZ, or possibly truncated at its northern margin. The imposition of a late, strong schist zone schistosity, and extreme deformation and attenuation of the lithological units in this area, precludes confident tracing of the F_1 axial plane trace. The domain of consistently upward-facing F_2 structures from the Brassey Tank North Antiform to the south suggests that the Himalaya Fold axial plane trace does not pass into this area.

However, if both the Thackaringa Loop East and Thackaringa East folds are antiformal and synformal respectively, as field inspection and interpretation suggest, then the stratigraphic interpretation indicates that these folds are upward-facing and lie on the upward-facing limb of the F_1 Himalaya Fold. Accordingly, the F_1 axial plane trace may pass south of the Thackaringa Loop East Antiform, as shown speculatively in Figs 3, 5, through a zone of poor outcrop, complex geology and northwesterly shearing. The structure and stratigraphy of this area require closer examination for a resolution of this problem.

The attitude of the Himalaya Fold has not been determined, due to a lack of outcrop in the hinge area, and of lithologies suitable for good development of D_1 structural elements. The geometry of the fold is also not directly observable although the structure appears to have a tight axial zone and broad limb areas. These features are consistent with the interpretation of F_1 folds throughout the Broken Hill Block as large-scale, isoclinal, probably recumbent (or nappe-like) structures (*c.f.* Majoribanks *et al* 1980).

North of the T-P SZ, the Quarry Tank - Whites Well area is also a domain of upward-facing F_2 structures, indicating that this area lies on the upward-facing limb of a single F_1 fold. The stratigraphy and structure of the Bald Hill - Little Paddock Well area is not well known and structural facing cannot be interpreted in this area.

Second Generation Folds

The distribution of F_2 macroscopic folds is shown in Fig 3. The D_2 age of these structures is determined by overprinting criteria : they all deform S_1 (e.g. gneissosity in quartzo-feldspathic gneisses) and many have superimposed F_3 folds or S_3 schistosity. South of the T-P SZ for example, the east - to northeast-trending F_2 folds deform S_1 in a number of lithologies (amphibolite, leucogneiss, etc.) and are themselves overprinted by a variably developed S_3 schistosity or by meso- to macroscopic F_3 folds (Figs 3,4). The dome-and-basin structures developed in the Old Coolgardie North and South folds are due to plunge reversals caused at least partly by broad warping of the F_2 structures by open macroscopic F_3 folds (Fig 3).

F_2 macroscopic folds south of the T-P SZ tend to be open, broad structures, although some are isoclinal (Camels Humps Antiform, Big Hill Synform). Their axes plunge moderately to steeply to the east or northeast: the Big Hill Synform plunges 66/034 and the Brassey Tank North Antiform plunges 65/073. The interaction of these folds with the T-P SZ varies from structure to structure. The Brassey Tank North Antiform has been sheared in the hinge zone by the T-P SZ. The Big Hill Synform is truncated by the schist zone to the east of the Thackaringa area (Brown 1978). The Thackaringa East Fold, possibly an extension of the Brassey Tank South Synform, has an axial trace which appears to parallel the schist zone (Fig 3).

In most instances, the F_2 folds shown in the south Thackaringa district in Figure 3 are delineated by continuous lithological or stratigraphic markers, with clearly exposed hinge zones in which bedding and schistosity S_1 are folded. In some cases however, the F_2 closures are not exposed, in which case symmetry of the lithological or stratigraphic markers is used to define the structures. The Brassey Tank South Synform is defined by a symmetry of Broken Hill Group and Himalaya Formation lithologies about a core of Sundown Group metasediments; the closure of this fold to the north is obscured in the T-P SZ. Near Camels Humps, the Camels Humps Antiform is inferred on the basis of symmetry of Cues Formation lithologies (particularly leucogneiss - see Fig 5 of Willis, 1982) about a core of mega-crystic gneiss (Alma Gneiss) and leucocratic sodic plagioclase+quartz rocks (Lady Brassey

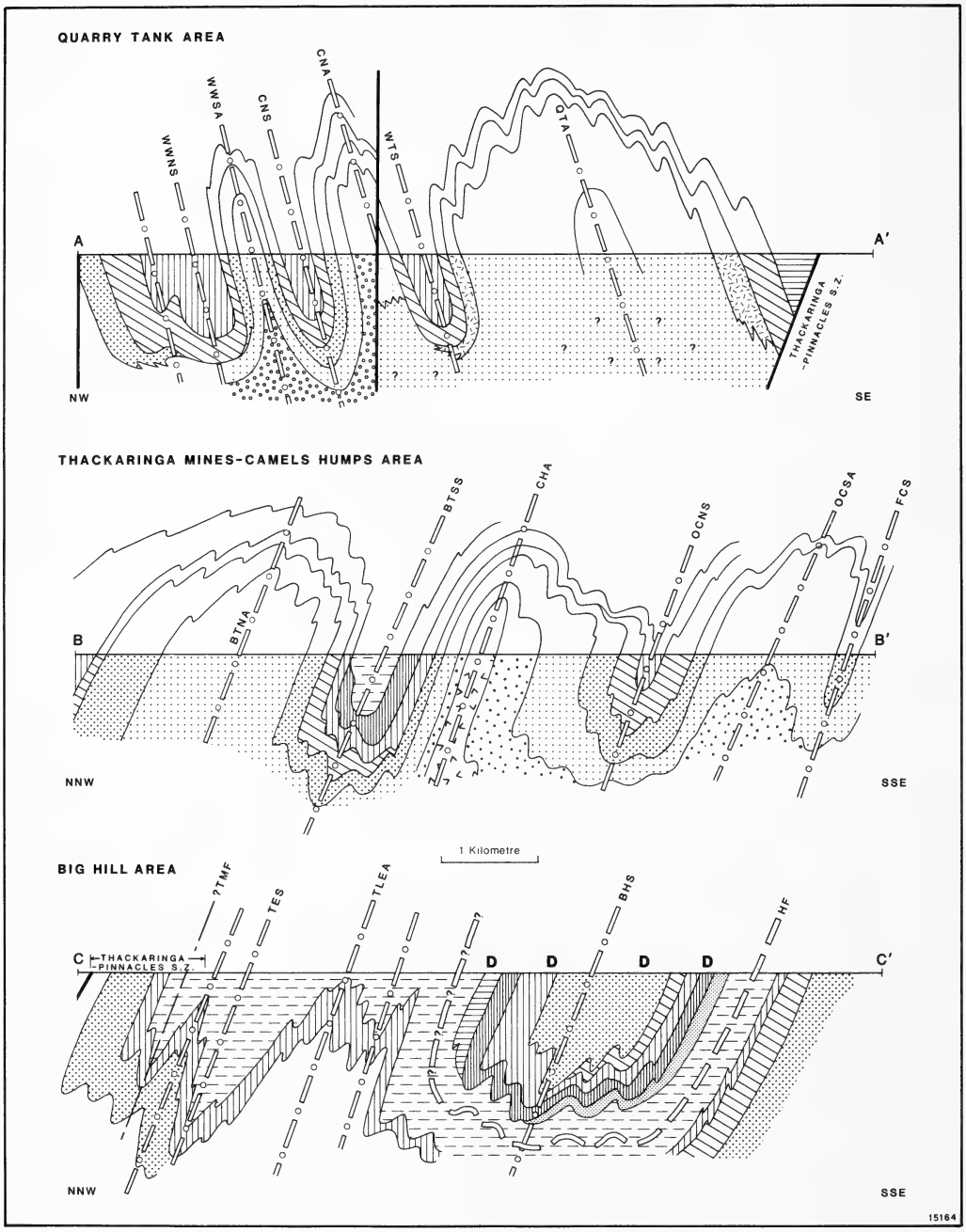


FIG. 5. Cross sections of the stratigraphy and structure in three areas of the Thackaringa district. Sections are diagrammatic only, and are not to scale vertically. Reference as for Figs. 2, 3. Sections located on Fig. 3. Note that section C-C' presents an interpretation based on the speculative distribution of the Himalaya Fold shown in Fig. 3.

Formation). An exceptionally strong north-plunging biotite lineation obscures the S_1, S_2 schistosity relationships in the hinge zone in the Alma Gneiss, a feature which Archibald (1978) concluded was typical of F_2 structures. To the east, beyond the Alders Tank Fault, the closure of the Camels Humps Antiform is clearly defined in an open east-plunging structure by folded S_0 and S_1 in Himalaya and Cues Formation rocks (Fig 3).

In the central part of the area, southeast of Twenty Mile Tower, a zone of complex structures is present which is poorly understood. This zone comprise an area of interaction of mainly F_2 folds, and structures associated with the east-trending T-P SZ. The continuity and correlation of the F_2 axes in this area are uncertain.

North of the T-P SZ, F_2 folds tend to be tight to isoclinal, with northeast-trending axes (Fig 3). In the Whites Well area, a series of isoclinal F_2 folds has caused rapid repetition of stratigraphy. These folds are delineated by lithostratigraphic marker units (especially leucogneiss) and by vergence relationships of minor folds. F_2 closures are only clearly exposed in the Whites Well North Antiform (where the hinge is defined by amphibolite and quartz+feldspar+biotite+garnet gneiss), and in the Quarry Tank Antiform (Fig 3). The Cues South Fold (Fig 3) is interpreted on the basis that the rocks southeast of Whites Well are a core of Thorndale Composite Gneiss migmatitic rocks. Because the stratigraphy must young to the northwest and southeast, an F_2 hinge is interpreted in this area. The hinge may have been truncated or dislocated by a strong schist zone which trends to the northeast (Fig 3).

Third Generation Folds

Macro- and mesoscopic F_3 folds are open, rounded, concentric style folds with S_3 axial planar. North of the T-P SZ macroscopic F_3 folds are common, with their axial plane traces at a high angle to the regional northeast trend (Fig 3). These macroscopic folds plunge steeply to moderately to the north and south, with subvertical axial planes which strike northwest to northeast. Retrograde schist zones occur in the limbs of these F_3 folds (e.g. northeast of Whites Well), in some places acting as faults or slides displacing or attenuating F_3 fold limbs.

In the south Thackaringa district, macroscopic F_3 folds are also present (Fig 3). The Ram Paddock Antiform is the largest F_3 structure in the area, and deforms the F_2 Camels Humps Antiform and schistosities S_1 and S_2 (Fig 4). The axial plane trace of this fold probably continues to the south where interference with the F_2 Old Coolgardie North Synform may account for the "basin" structure in this area. North to northeast trends predominate for macroscopic F_3 folds in the south Thackaringa district.

Fourth Generation Folds

A single macroscopic F_4 fold has been definitely recognized, in the area northeast of Camels Humps (Figs 3,4). This fold, the Thackaringa Loop Synform, plunges 75/064. It deforms the axial surface of the F_3 Ram Paddock Antiform and is itself truncated by a north-trending fault (Fig 4). Other east- or east-northeast-trending macroscopic F_4 folds may occur in the south Thackaringa district, but they would be difficult to detect unless they could be seen to overprint F_3 elements.

Macroscopic Folds in the Thackaringa-Pinnacles Schist Zone

Macroscopic folds are present in the T-P SZ, defined by horizons of amphibolite and associated quartz-feldspar+biotite+garnet gneiss of the Broken Hill Group (Fig 2) (Willis *in prep.*). The fold form surfaces are difficult to trace in detail because of dislocation and attenuation within the schist zone, but the distribution of probable axial traces is shown in Fig 3.

The Twenty Mile Fold has a clearly defined hinge zone near Twenty Mile Tower, and is probably synformal, plunging to the east, and of $?F_2$ age. The hinge zone is extremely attenuated and is smeared out within the schist zone to the west. The fold may close to the east near the Triple Chance road where lithological and bedding trends transgress the strike of the schist zone. Alternatively the fold may extend further to the east through the zone of complex structures which lie southeast of the road (Fig 3).

On stratigraphic grounds a major series of folds (including the Thackaringa East Fold) can be postulated lying subparallel to the eastern T-P SZ. This fold is indicated by a symmetry about a core of pelitic to psammopelitic metasediments (Sundown Group), flanked by amphibolite with quartz+feldspar+biotite+garnet gneiss (Broken Hill Group), and sodic plagioclase+quartz rocks (Himalaya Formation) (Fig 2). The northern limb of this gross structure as defined by the sodic plagioclase+quartz rocks, can be traced as far westwards as Little Paddock Well, accompanied by the Broken Hill Group rocks. The axial plane trace of the Thackaringa East Fold is possible an extension of the Brassey Tank South Synform, with companion F_2 structures (including the Twenty Mile Fold) to the north (Fig 3). The highly sheared northern limb of the T-P SZ represents one limb of this large structure or set of structures, and may possibly represent a macroscopic tectonic slide (Willis, *in prep.*).

The age of the macroscopic structures in the schist zone cannot be confidently determined. The interpreted continuation of the Brassey Tank South and Thackaringa East Synforms suggests that this structure is at least F_2. Structures in the T-P SZ are at least post D_1 since they overprint S_1 gneissosity in quartzo-feldspathic rocks at Little Paddock Well (Willis *in prep.*). Deformation in the zone continued well after D_2 and D_3, however, since the T-P SZ truncates F_2 and F_3 structures along its northern margin.

MACROSCOPIC INTERFERENCE PATTERNS

In the vicinity of the F_1 Himalaya Fold axial plane trace, a lobate F_1/F_2 fold interference pattern is developed that resembles the Type 2 patterns of Ramsay (1967, Fig 10-13). This is interpreted to be due to upright F_2 structures being superimposed on a relatively regular, inclined to recumbent, F_1 fold limb.

In the Old Coolgardie Tank area, a more open dome-and-basin type pattern is thought to be due to imposition of north-trending F_3 folds on upright and tight to open east-trending F_2 folds (a pattern transitional between Types 1 and 2 of Ramsay, 1967). Because this area lies on the single limb of a major F_1 structure, the effects of D_1 can be ignored. Similarly, F_1 structures have not apparently affected the macroscopic pattern of folds north of the T-P SZ, where the pattern of isoclinal to tight, northeast-trending upright F_2 structures has only been marginally distorted by the interference of north-trending macroscopic F_3 structures. In the T-P SZ itself, a component of extreme ductile deformation has tended to attenuate and distort the fold interference pattern.

DISCUSSION

The complex pattern of macroscopic folds in the Thackaringa area can be related to interference of three main fold generations: D_1, D_2 and D_3. At meso- and macroscopic scales, the structural elements of these three deformations can be correlated with the main structural elements from similar phases of deformation documented in the northern and central Broken Hill Block. In the Thackaringa area, the macroscopic interference pattern is due mainly to tight F_2 folding, modified by superimposition on F_1 structures, and/or by later F_3 folding. A fourth generation of macroscopic folding (D_4, F_4) also appears to be present in the south Thackaringa district, but the regional extent of this folding is not known. It is concluded that there does not appear to be a substantial difference in deformation generations and structures between the south-western, and the northern and central, Broken Hill Block.

In addition, the structural elements observed in the bedded rocks and gneisses of the Thackaringa Group in the Thackaringa area, can be directly correlated with those observed in the overlying Broken Hill and Sundown Groups, both at Thackaringa and in the central and southern Broken Hill Block. This supports the observations of others (e.g. Laing *et al* 1978), that there are no differences in structural elements within this section of the Broken Hill Block stratigraphic sequence. It also confirms the suggestion (Stevens *et al* 1983) that there does not appear to be an angular unconformity at the major Thackaringa Group/Broken Hill Group boundary.

The easterly-trending, open, "egg-carton" type macroscopic interference pattern present in the south Thackaringa area contrasts with the dominantly northeast-trending tighter pattern of much of the remainder of the Broken Hill Block, including the Thackaringa area north of the T-P SZ. This appears to be either due to an originally east-oriented system of relatively open to tight F_2 folds, or, less likely, to later reorientation of these folds. It can be speculated that this easterly orientation of structures was at least partly controlled by the Thackaringa-Pinnacles SZ. This is proposed because of domain of "egg-carton" interference structures is bounded by the T-P SZ in the north, and by a parallel major lineament in the south (the Felspar Creek lineament, which occurs just south of the Felspar Creek Synform in Fig 3) (Willis 1980a, in prep.). The more typical northeasterly trends predominate north and south of these structures. In addition, the major F_2 axes are subparallel with the T-P SZ and Felspar Creek lineament, supporting a possible relationship between these folds and the planar structures. This would support an earlier suggestion (Willis 1980a, in prep.) that the T-P SZ may represent a structure of at least D_2 age.

Future work in the area should involve resolution of the distribution of the F_1 axial plane trace, and more detailed studies in key areas to more carefully resolve the distribution of the proposed structures.

ACKNOWLEDGEMENTS

This paper has been greatly improved by the helpful comments of B. Stevens, J. Stroud and R. Barnes. I would also like to thank B. Stevens for his assistance with aspects of the interpretation, H. Basden for her advice and an anonymous reviewer for useful criticism. The diagrams were prepared by Cartographic Section of the Geological Survey of N.S.W.

REFERENCES

Archibald, N.J., 1978. Stratigraphic controls on Pb-Zn sulphide mineralization in the Proterzoic Willyama Complex. *Report to Broken Hill Mining Managers Association* (unpubl.).

Borradaile, G.J., 1976. "Structural facing" (Shackleton's rule) and the Palaeozoic rocks of the Malaguide Complex near Velex Rubio, S.E. Spain. *Proc. K. Akad. Wet. Ser. B*, 79, 330-336.

Brown, R.E., 1978. Geology of the Pinnacles 1:25,000 sheet area, Broken Hill, New South Wales. *Rep. geol. Surv. N.S.W., GS 1978/057* (unpubl.).

Brown, R.E., 1980. The geology of the Broken Hill 1:25,000 sheet area, Broken Hill, N.S.W. *Rep. geol. Surv. N.S.W., GS 1980/143* (unpubl.).

Brown, R.E., Stevens, B.P.J., Willis, I.L., Stroud, W.J., Bradley, G.M., and Barnes, R.G., 1983. 3. Quartzo-feldspathic rocks, *in* ROCKS OF THE BROKEN HILL BLOCK: THEIR NATURE, STRATIGRAPHIC DISTRIBUTION AND ORIGIN. *Rec. geol. Surv. N.S.W., 21(1)*, 127-224.

Hobbs, B.E., 1963. The structural environment of the northern part of the Broken Hill orebody. *J. geol. Soc. Aust., 13(2)*, 315-338.

Laing, W.P., Marjoribanks, R.W., and Rutland, P.W.R. 1978. Structure of the Broken Hill mine area and its significance for the generation of the orebodies. *Econ. Geol., 73(6)*, 112-1136.

Marjoribanks, R.W., Rutland, R.W.R., Glen, R.A., and Laing, W.P., 1980. The structure and tectonic evolution of the Broken Hill region Australia. *Prec. Res., 13*, 209-240.

Ramsay, J.G., 1967. FOLDING AND FRACTURING OF ROCKS. McGraw Hill, New York. 568pp.

Rutland, R.W.R., and Etheridge, M.A., 1975. Two high-grade schistosities at Broken Hill and their relation to major and minor structures. *J. geol. Soc. Aust., 22(3)*, 259-274.

Stevens, B.P.J., 1980. Introduction, *in* Stevens, B.P.J., (ed.) A GUIDE TO THE STRATIGRAPHY AND MINERALIZATION OF THE BROKEN HILL BLOCK, NEW SOUTH WALES. *Rec. geol. Surv. N.S.W., 20(1)*, 1-7.

Stevens, B.P.J., Stroud, W.J., Willis, I.L., Bradley, G.M., Brown, R.E., and Barnes, R.G., 1980. A stratigraphic interpretation of the Broken Hill Block, *in* Stevens, B.P.J., (ed.) A GUIDE TO THE STRATIGRAPHY AND MINERALIZATION OF THE BROKEN HILL BLOCK, NEW SOUTH WALES. *Rec. geol. Surv. N.S.W., 20(1)*, 9-32.

Stevens, B.P.J., Willis, I.L., Brown, R.E., and Stroud, W.J., 1983. The Early Proterozoic Supergroup: definitions of stratigraphic units from the Broken Hill Block, New South Wales. *Rec. geol. Surv. N.S.W., 21(2)*, 407-442.

Stroud, W.J., in prep. The geology of the Triple Chance 1:25,000 sheet area, Broken Hill. Rep. geol. Surv. N.S.W. (in prep.).

Williams, P.F., 1967. Structural analysis of the Little Brown Hill area, New South Wales. *J. geol. Soc. Aust., 14(2)*, 317-331.

Willis, I.L., 1980a. Geology of the Thackaringa 1:25,000 sheet area, Broken Hill, New South Wales. *Rep. geol. Surv. N.S.W., GS 1980/139* (unpubl.).

Willis, I.L., 1980b. Stratigraphic interpretation of the Silverton-Thackaringa area, *in* Stevens, B.P.J., (ed.) A GUIDE TO THE STRATIGRAPHY AND MINERALIZATION OF THE BROKEN HILL BLOCK, NEW SOUTH WALES. *Rec. geol. Surv. N.S.W., 20(1)*, 121-127.

Willis, I.L., 1982a. Description and interpretation of a useful leucogneiss stratigraphic marker in the Willyama Complex, Broken Hill Block, N.S.W. *R. Soc. N.S.W., Proc., 115*, 21-32.

Willis, I.L., 1982b. Stratigraphy of the Thackaringa Group (Suite 3), Willyama Supergroup, Broken Hill Block, *Rep. geol. Surv. N.S.W., GS 1982/261* (unpubl.).

Willis, I.L., in prep. The Thackaringa-Pinnacles Schist Zone, a major brittle-ductile shear zone in the Broken Hill Block N.S.W., Australia.

Willis, I.L., Brown, R.E., Stroud, W.J., and Stevens, B.P.J., 1983. The Early Proterozoic Willyama Supergroup: stratigraphic subdivision and interpretation of high to low-grade metamorphic rocks in the Broken Hill Block, N.S.W. *J. geol. Soc. Aust., 30*, 195-224.

Geological Survey of New South Wales,
Armidale Office,
C/- Department of Geology and Geophysics,
University of New England,
Armidale, N.S.W. 2351. Australia

(Manuscript received 29.2.1984)
(Manuscript received in final form 14.11.1984)

Journal and Proceedings, Royal Society of New South Wales, Vol. 117, pp. 99-111, 1984
ISSN 0035-9173/84/020099 — 13 $4.00/1

Chiral Discriminations and Molecular Propellers

ROBERT S. VAGG

ABSTRACT. The nature of molecular chirality and the control of discriminatory interactions between chiral molecules are discussed in general with some emphasis on tetrahedral and octahedral stereochemistries. In particular recent studies on a series of ternary ruthenium(II)-diimine complexes with optically active α-amino acids which contain both of these stereochemistries as chiral centres is reviewed. These systems are photo-labile and equilibrate on irradiation with visible light so as to reflect in their equilibrium constants chiral discrimination energies between diastereoisomeric pairs. These energetic results are used to demonstrate the various discriminatory effects of different substituents on the amine-nitrogen and α-carbon atoms of the amino acids. Examples are given also of stereoselective control of reactions at the coordinated amino acid bidentate ligands.

INTRODUCTION

Symmetry and Chirality

Many aspects of human existence, including man's natural environment, appearance, perceptions and intellectual pursuits are influenced by the concept of **symmetry**. Its perception in nature and its manifestation in art has persisted throughout man's history and has acted as a base for much of his music, architecture, painting and verse. Its value to engineering and the sciences stems at least from the analyses of Pythagoras, and symmetry theory now has assumed a fundamental significance to natural philosophy as a whole (Shubnikov and Koptsik, 1974).

The word **symmetry** derives from the Greek root **métron**, meaning 'to measure', and the prefix **syn** or **sym** meaning 'with' or 'together'. The concept, therefore, is a comparative one which describes the characteristic of a pattern or object whose constituent parts have some measure of similarity which results in a regularity of form. Thus a symmetrical object may be perceived as being derived from two or more similar irregular or asymmetric parts; the special relationship between these parts, and their number, define the object.

The external features of living matter usually exhibit elements of symmetry, although often imperfect, with higher orders of symmetry generally occurring in the lower life forms. Almost all vertebrates, including man, exhibit an approximate bilateral symmetry with the left and right sides related by an imaginary mirror operation. This concept of a dimension reversal is important, for the description of two objects as being either "left" or "right" denotes that they are not superimposable and yet are in all other ways identical. Such objects are termed **chiral**, possessing the asymmetric property of **chirality** , or 'handedness', which again has a Greek derivation (**cheír** meaning 'hand').

In general the symmetry of external forms of matter reflect the degree of geometrical simplicity present at a molecular level. The complex structured molecules of living organisms such as sugars, proteins and nucleic acids are all chiral, with in general only one left- or right-handed form being employed. The basic structuring element of these molecules is carbon, whose abundance and chemical bonding properties are ideal in terms of generating the desired stability and molecular stereochemistries.

MOLECULAR CHIRALITY

A rigorous mathematical description of symmetry involves the use of symmetry **elements** and symmetry **operations**. At a molecular level the two important symmetry elements that may be used to fully describe the geometrical properties of a molecule are the **proper** (or **rotation**) **axis**, given the symbol C_n, and the

---

* Presidential Address delivered before the Royal Society of New South Wales at Macquarie University on April 4, 1984.

improper (or **rotation-reflection**) **axis,** S_n. In a purely descriptive sense the commonly used **mirror** plane (σ) and **centre** of symmetry (i) elements are equivalent to improper axes of order (n =) 1 and 2 respectively. The absence of the symmetry elements σ and i is often taken by chemists as the sole requirement for chirality (optical activity) in a molecule. However, this test is an incomplete one, for **the fundamental stereochemical requirement for a molecule to exhibit optical activity is the absence of an improper** (S_n) **axis,** and indeed optically inactive substances are known whose molecules contain neither a centre nor mirror symmetry element. Detailed descriptions of the analysis of molecular symmetry have been provided by Cotton (1971) and Mead (1974).

The simplest three-dimensional molecule that may be chiral is one containing three different atoms bonded to a central atom to form a triangular pyramid (Fig. 1). The central atom is then termed a **chiral centre** and the asymmetric face may be viewed as the basic source of this chirality. Chiral tricoordinate centres based on a nitrogen atom in general show rapid inversion , although the energetic barrier to this inversion may be heightened by structural and electronic factors so as to allow configurational stability. This is a common situation in many naturally-occurring alkaloids, for example, where the nitrogen atoms lie at the junction of inflexible bridged ring systems (Bentley, 1982).

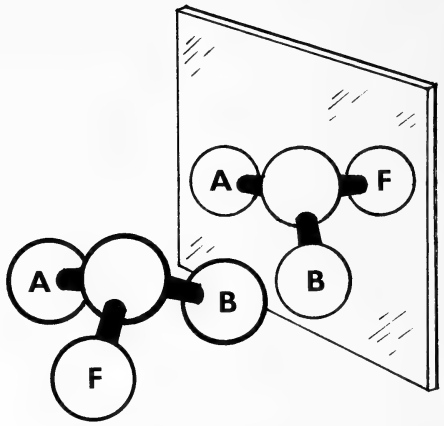


Fig. 1 Representation of the left- and right-handed forms of a chiral triangular pyramidal molecule.

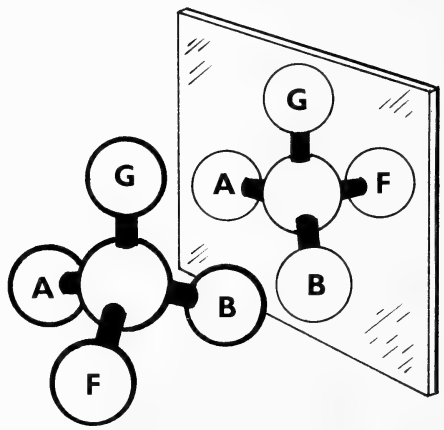
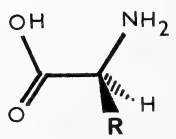


Fig. 2 Representation of the two hands of a tetrahedral chiral molecule.

Tetrahedral Chiral Centres

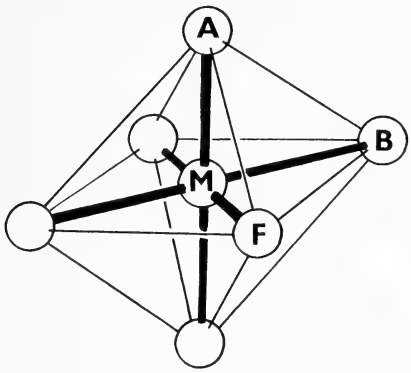
The most common source of chirality in biological molecules is the tetracoordinate carbon atom bearing four different substituents with the resulting two isomeric forms (**enantiomers**) being non-superimposable (Fig. 2). If two or more of these subsituent groups (A,B,F and G in Fig. 2) were to become equivalent then, in general, the tetrahedral centre would loose its chirality due to the consequent gain of an internal mirror plane. Good examples of these types of molecules are the α-amino acids, represented by the general formulae shown in **I**, which are the basic constituents of peptides, proteins and most enzymes. All naturally occurring α-amino acids except glycine (**I** with R = H) are chiral, but with very few exceptions proteins in plants and animals are made up of only the "left-handed" (L or S) forms.

Several nomenclature systems have evolved in order to describe the absolute configuration at a tetrahedral chiral centre. The most systematic, and therefore of most general use, is that of Cahn, Ingold and Prelog (1956 and 1966) in which the designations R (rectus) and S (sinister) are employed. This system is based on a sequence rule which allows assignment of a hierarchical order for the four substituents and which in turn is determined by the atomic numbers of

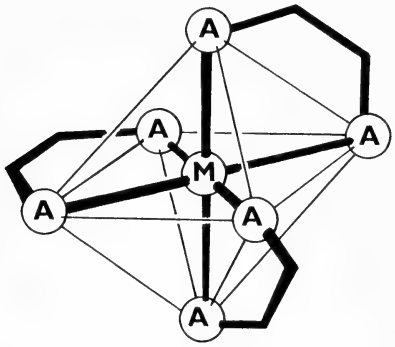


S-amino acid

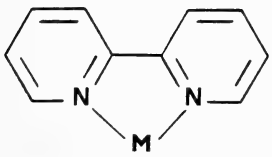
(I)



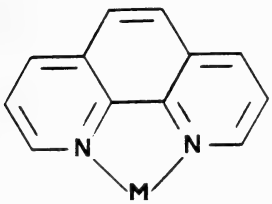
(II)



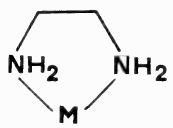
(III)



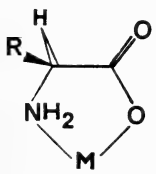
2,2'-bipyridine (bipy)



1,10-phenanthroline (phen)



1,2-diaminoethane (en)



L(S)-α-amino acid (aa)

Fig. 3 Some common five-membered chelate rings.

their constituent atoms. Unlike earlier systems it is neither dependent on the chiroptical properties of a substance nor on a structural comparison with other specific molecules, and it may be used to define unequivocally several chiral centres in one molecule. Excellent detailed descriptions of these methods of configurational designation are provided by Alworth (1972) and Testa (1982).

Octahedral Chiral Centres

One of the most common bonding geometries adopted by metal ions is the octahedron, in which the metal is hexacoordinate and surrounded by six bonding atoms capable of electron donation to the central cation. Such a structure allows for several different isomeric forms through various combinations of identical and different substituent groups, or **ligands.** Again in a molecule of this geometry one of the most conceptually simple chiral forms would be that in which three different monodentate ligands are arranged at the corners of one triangular face, as shown in **II**, a feature similar to the pyramidal and tetrahedral examples discussed above. This chirality could be lost, however, by adding certain combinations of one or more of the same substituents in the remaining three positions of the octahedron so as to introduce an element of symmetry (mirror or centre) into the molecule.

In reality this is a little-studied form of chirality at an octahedral metal centre. A far more common form is that generated by the use of **bidentate** ligands - molecules containing two donor atoms capable of bonding to the same metal ion and thereby linking two adjacent positions on one edge of the octahedron (shown in **III**). As a result the metal ion becomes one member of a small molecular ring (a **chelate** ring) which usually contains five or six atoms. Examples of some molecules which commonly perform this function are shown in Figure 3, and include all the α-amino acids.

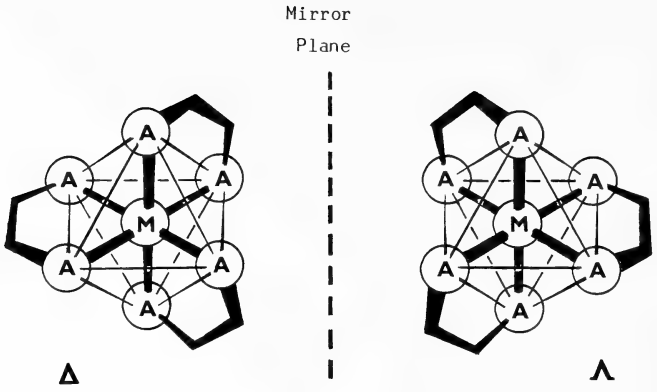


Figure 4 Representation of the Δ and Λ enantiomers of a complex of the type $M(A\frown A)_3$ viewed down the three-fold (C_3) symmetry axis.

Molecular Propellers

If either two or three bidentate molecules coordinate to the one metal ion the resulting chiral structure has a helical or propeller shape (Fig. 4). Again, like the tetrahedron, several conventions have been used to describe the absolute configurations of such molecules. The now commonly accepted (IUPAC) convention is to define the enantiomer which adopts a right-handed propeller as the Δ (delta) form, the left-handed enantiomer being the Λ (lambda) form. Several detailed reviews on the stereochemistry of chiral metal complexes have been published; for additional information the reader is referred to those of Gillard and Mitchell (1970) and Saito (1979).

CHIRAL DISCRIMINATIONS

The ability of living systems to discriminate between different isomeric forms of the one substance has been known for more than a century. Pasteur, for example, was able to demonstrate in 1860 that the action of a yeast on his racemic ammonium tartrate salt caused only the right-handed form to ferment, leaving the left salt untouched (Bentley, 1982). The pain-killing drug morphine is active only in the left-handed form, the other enantiomer being neither physiologically active nor addictive (Bernal et al, 1972). The selective nature of the action of enzymes also is based on the ability of those molecules to discriminate enantiomers either in recognitive or synthetic roles. Thus a racemic species which is chemically pure when introduced into a living system is recognised as having two different molecular structures, and the two enantiomeric forms may have completely different physiological effects. This highlights the difference between an achiral (symmetrical) environment (in vitro) and a chiral (in vivo) environment, a distinction that may be sensed only by chiral molecules.

Ideal models to demonstrate the nature of this discriminatory effect are the human hands. These will each interact in an equivalent manner with an object that is achiral, for example a tennis ball. However, if a chiral object such as a leather glove designed for the right hand is chosen then this equivalence is lost and a right-right selective interaction occurs. A left hand may be forced into a right-hand glove but this involves expenditure of additional energy. This process is mimicked at the molecular level. Two enantiomers will interact equally with a molecule such as water which is achiral. However, if this second molecule is chiral then the two possible interactions are no longer equivalent and the one which leads to the more thermodynamically stable interaction product will be preferred. The process thus becomes discriminatory.

Like all chemical processes the control of these interactions is under energetic influences and the chosen end-product or reaction intermediate reflects that having the highest thermodynamic stability (or the lowest overall free energy state). If the difference in energy between two possible products is sufficiently large then the process becomes completely selective towards one alone. This discriminating ability acts as the foundation for many of the physical and chemical properties of chiral molecules, including their interaction with polarized light and crystallization and resolution processes (Craig and Mellor, 1976; Craig, 1980; Mason, 1982).

Again the classic resolution of sodium ammonium tartrate by Louis Pasteur may be used

to demonstrate how such interactions may be energetically controlled. Crystallization of that racemic salt from solutions below 28°C results in the separation of a 1:1 mixture of hemihedral crystals which each contain molecules of either the left- or right-handed form only (Feiser and Feiser, 1944). Each crystal shows corresponding optical activity. Hence under these conditions the left-left and right-right interactions are preferred (equally) and the salt spontaneously resolves. Crystallization at higher temperatures results in symmetrical racemic crystals separating from solution which, like the mother liquor, are optically inactive. In these latter circumstances a left-right interaction is energetically preferred.

The chemical resolution of a racemic mixture of ions into its two optically active components is usually achieved by introducing a suitable chiral reagent (a resolving agent) into the system which can selectively interact with one of the two enantiomeric forms and precipitate it as a less soluble salt. The resulting solid product is called a **diastereoisomer,** having at least two different chiral centres. Its separation from solution reflects the better molecular packing and consequent higher crystal lattice stability of that salt (Craig, 1974).

Similarly, the property of optical activity - the ability of a chiral substance to rotate the plane of polarized light - may be viewed as a chiral discriminatory process. Plane (or linearly) polarized radiation is composed of two in-phase but oppositely rotating beams of circularly polarized radiation (Lambert et al, 1976). The transverse vibrations of the latter trace out right- and left-handed helices as a function of time. The velocity of each of these components are equal in achiral media but will differ when passing through an optically active medium. As a result the two components will emerge out of phase and this is observed as a rotation of the original plane of polarization. This phenomenon therefore may be veiwed as an example of a chiral form of matter discriminating between the two components of a "racemic" form of energy.

DIASTEREOISOMERIC METAL COMPLEXES

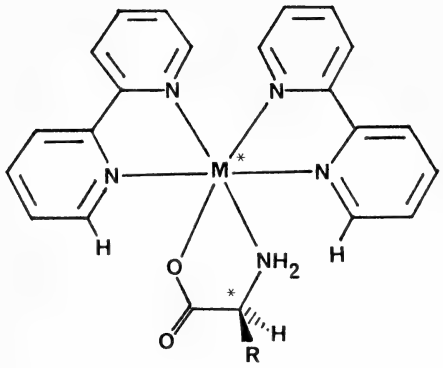
Since the early part of this century the resolution of chiral octahedral metal ions has played a fundamental role in the development of theories of structure and bonding in transition metal chemistry. The optical resolutions of Alfred Werner and his students have been described as "a stereochemical achievement of the highest order" and they provided the basis for the new field of coordination chemistry (Kauffman, 1974). Most of these resolutions involved the use of asymmetric tartrate or substituted-tartrate anions to select one hand of a metal complex cation and thus form a diastereoisomeric salt. An excellent example of how this selective association may occur is provided by the crystal structure of the Λ-[Co(en)$_3$]Br(d-tart) salt reported by Kushi et al (1976). Here the d-tartrate resolving anion can be seen to effectively hydrogen-bond only the lambda-propeller of $[Co(en)_3]^{3+}$ through three amine groups on one octahedral face. As a result this propeller is precipitated selectively from a racemic solution as the Λ,d-diastereo-isomer.

Contributions of F.P.Dwyer

Several fundamental contributions to the field of chiral metal complexes were made in Australia during the 1950's by F.P.Dwyer and his colleagues (Mellor, 1970). A large proportion of this much-cited research was published in the Journal and Proceedings of this Society and some are judged throughout the world to be classic papers in coordination chemistry. This contained significant work on the metal complexes of the bidentate diimine bases 1,10-phenanthroline (phen) and 2,2'-bipyridine (bipy) (see Fig. 3) and included the resolutions of the tris-diimine complexes of bivalent Fe, Ni, Ru and Os. The inert osmium(II)/(III) complexes were used to demonstrate the existence of electron transfer and dynamic equilibria between the resolved ions. The properties of solutions of the Ru and Ni enantiomeric cations in the presence of other chiral ions were used to introduce the concept of 'configurational activity' - a form of chiral discrimination resulting from non-bonded interactions between chiral species in solution (Dwyer et al, 1955; Barnes et al, 1955). The discovery of the different activities of enantiomeric forms of these and closely related complexes in biological systems was a natural extension of Dwyer's fundamental research on these chiral metal chelates (Mellor, 1970; Dwyer, 1959; Shulman and Dwyer, 1964).

PHOTOLABILE RUTHENIUM SYSTEMS

The type of molecular interactions described by Dwyer, like the general use in coordination chemistry of asymmetric anions as resolving agents, usually involve a discriminating function between a propeller cation and an anion containing a tetrahedral chiral centre. In 1980 a collaborative project between researchers at Macquarie University and University College Cardiff was begun on a series of cationic complexes of ruthenium(II) which contain both the metal and a carbon atom as chiral centres in the **one** molecular species. These diastereoisomeric cations, which resemble many of the compounds investigated by Dwyer, have general formula $[Ru(diimine)_2(aa)]^{n+}$ (where diimine is either phen or bipy and aa represents an α-amino acid) and are represented by the structural formula shown in **IV** . The remainder of this Address will centre on some of the results of investigations on these compounds. Closely



(IV)

related complexes have received substantial recent study due to their potential use as catalysts in solar energy storage systems (Kalyanasundaram, 1982).

These chiral cations were resolved using chromatographic techniques into their lambda and delta propeller forms (Vagg and Williams, 1981a & b). Moreover, the optically pure products obtained are photolabile, equilibrating on irradiation to selected lambda/delta ratios which reflect uniquely and accurately in their equilibrium constants the chiral discrimination energy difference between each pair of diastereoisomers (Vagg and Williams, 1981a; 1983).

Intramolecular Steric Interactions

Bulky α-carbon amino acid substituents were noticed to have a significant effect in determining the position of each equilibrium on irradiation. The observed preference for lambda diastereoisomers in equilibrated solutions of complexes of S-amino acids was explained in terms of a repulsive intramolecular steric interaction involving the acid substituent and one of the diimine molecules in the delta propeller (Vagg and Williams, 1981a). This situation is represented in Figure 5. Relief of steric strain in the delta form may be achieved on irradiation by inversion at the metal centre to produce the lambda stereoisomer, and hence the equilibrium lies significantly in this direction with bulky α-substituents (Vagg and Williams, 1981a; Goodwin, Vagg and Williams, 1984). This steric effect is enhanced if the α-methine hydrogen atom of the S-amino acid is substituted by a methyl group. As a result the preference for the lambda propeller is increased, with its thermodynamic stability relative to the delta form being increased by approximately $1.6 kJ mol^{-1}$ (Goodwin, Williams and Vagg, 1984). Not surprisingly, a further increased lambda preference is observed on changing the diimine ligand from bipy to the more inflexible phen base.

Evidence for the importance of steric effects in these species has been provided by the crystal structures of the two diastereoisomrs formed with bipyridine and S-alanine ligands. The comparative analysis of interatomic contact distances and bond-rotational distortions in these two cations demonstrate enforced steric strain in the delta form due to repulsive interactions involving the methyl group of the coordinated amino acid (Stephens et al, 1983). This observation is consistent with the measured chiral discrimination between this pair which energetically favours the lambda form (Vagg and Williams, 1983).

These complex species appear to be completely inert in the absence of light. Hence irradiation of a less-preferred delta

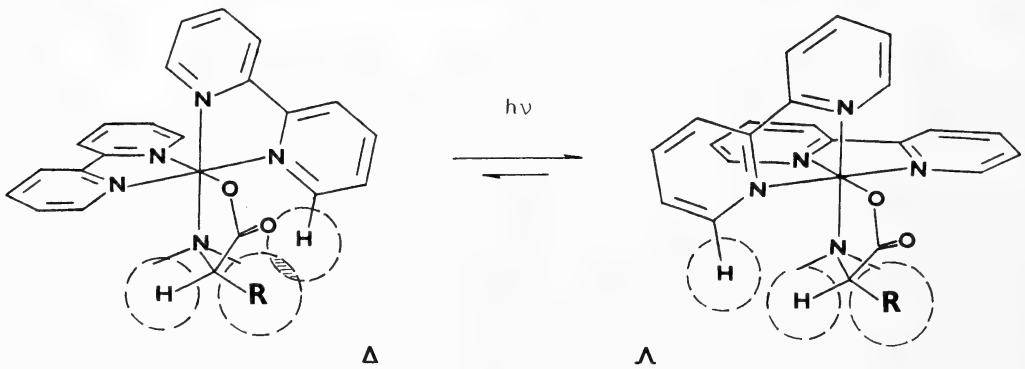
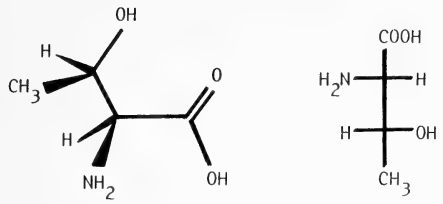
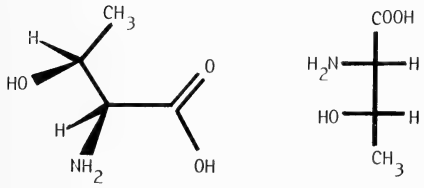


Figure 5 Photo-equilibration of the lambda and delta diastereoisomers of a complex of general form $[Ru(bipy)_2(S\text{-aa})]^{n+}$. The steric interaction between a diimine H atom and the amino acid side chain (R) in the Δ propeller is shown.



S-threonine



S-allothreonine

(V)

form, which incorporates this de-stabilizing interaction but which may be resolved and stored in the dark, immediately results in a reaction which generates the lambda propeller in high proportion. These isomerisation reactions provide examples of spontaneous inversion at a chiral centre which is unique in coordination chemistry.

Hydrogen Bonding Effects

There are several possible inter- or intramolecular interactions which may lead to discriminations between chiral molecules (Craig and Mellor, 1976; Craig, 1980). These include differential hydrogen bonding, short-range influences transmitted through one or more layers of solvent, and steric interactions similar to those mentioned above. The hydrogen bonding capacities of the amino acid side chains have been demonstrated to have a significant influence on the position of photo-equilibrium in these systems. Often this is sufficient to override the steric effect of the side chain and to produce an energetic preference for the delta propeller. This is evident in the selectivities demonstrated by the coordinated amino acids S-serine (Vagg and Williams, 1981b), S-glutamic

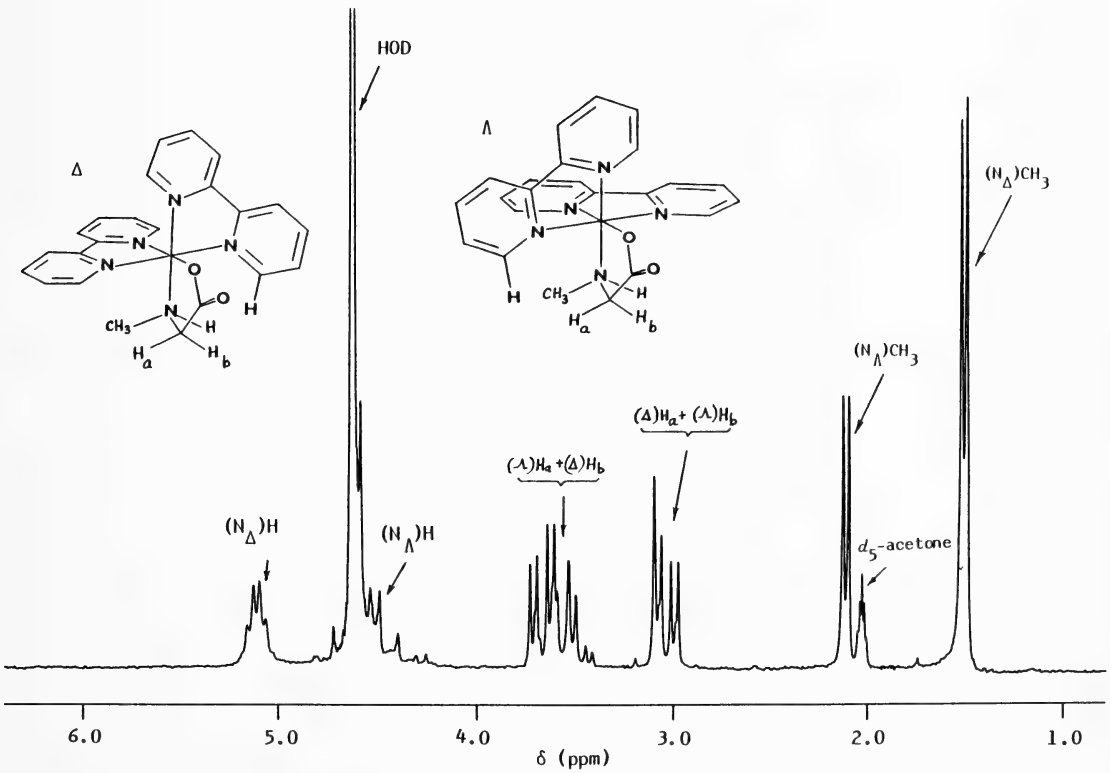
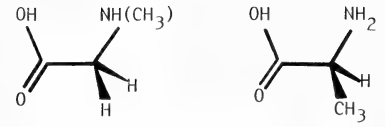


Figure 6 200MHz ^{1}H NMR spectrum of $[Ru(bipy)_2(N\text{-Me-gly})]^+$ isomers at equilibrium in 5:1 D_2O:d_6-acetone solution (Stark et al, 1984). (Enantiomeric pairs have been ignored)



N-methyl-glycine S-alanine

(VI)

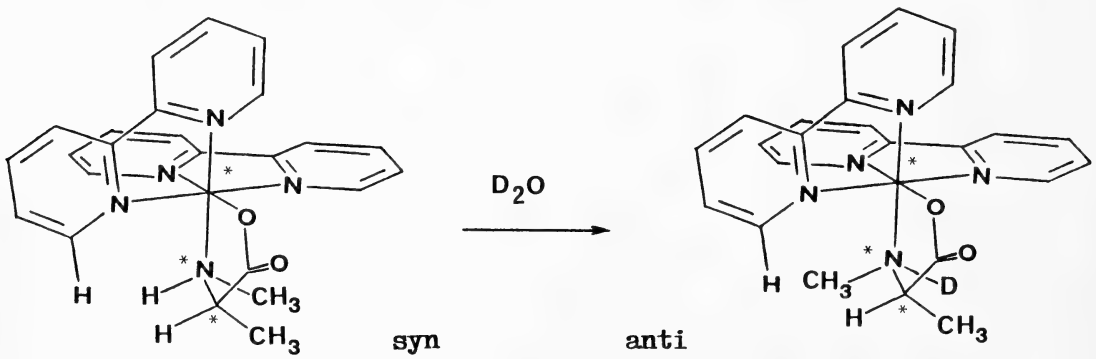
acid (Vagg and Williams, 1982a) and S-aspartic acid (Vagg and Williams, 1982b) in these complexes. Each contain a polar side chain capable of internally hydrogen bonding to the coordinated carboxylic group within the amino acid, and it is this hydrogen bond formation which has been suggested as having an overwheming influence on the respective photo-equilibration processes. The observed pH dependence of the equilibrium positions in the S-glutamic and S-aspartic acid systems is consistent with this postulate of bonding.

To test the competitive influences of these steric and hydrogen-bonding effects the Ru(II)-bis(diimine) complexes of S-threonine and S-allothreonine were synthesised (Goodwin, Williams, Stephens and Vagg, 1984). These two amino acids (**V**) differ only in the chirality of the β -carbon atoms, and hence any discriminatory effects due solely to the steric bulk of their side chains are negated. The crystal structures of the four bipy diastereoisomers provide evidence for intramolecular hydrogen bonding in the S-allo-threonine forms alone. This is consistent with the associated proton NMR and chiroptical analyses, and this structural difference is reflected in their measured chiral discrimination energies. Intramolecular hydrogen bonding is thus seen as a significant contributor to discriminatory effects in interactions between chiral molecules.

N-Substituted Amino Acid Complexes

Complexes of the naturally occurring amino acid S-proline demonstrate a high lambda-preference in these Ru-diimine systems (Vagg and Williams, 1984). This easily may be attributed to the severe steric effect which would result from the inherent substitution on the amine nitrogen atom of this acid. Indeed molecular models demonstrate that any substituent on the amine-N atom of an amino acid would have a much higher influence in these systems than the same substituent on the α-carbon atom. This fact may be evidenced in practice from a comparison of the equilibrium ratios of the $[Ru(bipy)_2(aa)]^+$ complexes with methyl substituents on these two atoms (respectively N-methyl-glycine and S-alanine, **VI**). The S-alanine complexes demonstrate an equilibrium ratio close to unity, with an energetic preference for the lambda isomer of only 0.52 $kJmol^{-1}$ (Vagg and Williams, 1983). By comparison the corresponding preference in the N-methyl-glycine system is 2.92 $kJmol^{-1}$ towards the stereoisomers which avoid a substituent-diimine interaction. If the amine-N substituent is increased in bulk to a rigid phenyl group ($-C_6H_5$) this process becomes completely selective (Stark et al, 1984).

The distributions of isomers in solution at equilibrium in these systems have been determined using a combination of circular dichroism and nuclear magnetic resonance techniques. An example of the use of the latter technique is provided by Figure 6 for an equilibrated solution of the N-methyl-glycine complexes. A corresponding spectral investigation of the S-alanine complexes has been reported recently (Vagg and Williams, 1983). In general the electronic shielding or deshielding by the aromatic diimine ligands causes sufficient differences in the observed chemical shifts of the amino acid protons to



Λ-|Ru(bipy)$_2$(N$_S$-Me-*S*-ala)|$^+$ Λ-|Ru(bipy)$_2$(N$_R$-Me-*S*-ala)|$^+$

Figure 7 Inversion of the absolute configuration of the coordinated amine-N atom accompanied by proton-deuteron exchange in N-methyl-S-alanine complexes.

allow their unequivocal assignment. For example the well separated resonance signals of the N-methyl groups in Figure 6 (δ = 1.5 and 2.1ppm) show an approximate 3:1 ratio which reflects the distribution of the corresponding isomers. Any structural changes or changes in isomeric ratios with time may be similarly followed.

An interesting additional discriminatory effect is observed when both the amine-N and α-carbon atoms of an amino acid are substituted. Having four different atoms bonded to it the coordinated methyl-substituted N atom becomes a third chiral centre in the molecule. As a result a secondary chiral discrimination may occur within the amino acid between the two substituent groups along the bond between the amine-N and α-carbon atoms. What is observed, in fact, is the eventual complete selection of isomers which contain these two groups in an anti configuration along this bond (Stark et al, 1984). Isomers which contain these two groups in a syn configuration are observed to undergo inversion at the amine nitrogen atom so as to relieve repulsive interactions along this N-C bond. This process, which is accompanied by amine proton exchange, is represented in Figure 7. It would be independent of these present systems and might be expected to occur in any metal complexes containing coordinated N-substituted amino acids. The chiral discrimination along this bond becomes an overiding one in these ruthenium systems, and the pronounced repulsion of the N-methyl substituent and the diimine ligand (Fig. 7) results in a significant delta preference for the ruthenium chiral centre on irradiation. This contrasts with the lambda preferences observed for unsubstituted S-amino acids mentioned earlier.

Some comparative data which demonstrate each of these discriminatory effects are given in Table 1. Glycine, an achiral amino acid, shows no discrimination with an equilibrium constant of unity as expected. Methyl-substitution of the α-carbon atom to give S-alanine results in a small preference for the lambda propeller. The bulkier amino acid S-tryptophan demonstrates a correspondingly higher lambda preference which may be increased further by substitution of the

TABLE 1

Λ/Δ Ratios (K_{eq}) on photo-equilibration[¶] in aqueous solutions together with indicated Chiral Discrimination Energies[*] ($kJmol^{-1}$)

Amino Acid (aa)[§]	R^1	R^2	R^3	R^4	*diimine*	K_{eq}	ΔG^*
glycine	H	H	H	H	bipy	1.00	0
N-methyl-glycine	CH_3	H	H	H	bipy	0.31	+2.92
N-phenyl-glycine	C_6H_5	H	H	H	bipy	†	†
S-alanine	H	H	CH_3	H	bipy	1.24	-0.52
N-methyl-*S*-alanine	CH_3	H	CH_3	H	bipy	0.62	+1.18
S-tryptophan	H	H	C_8H_7N	H	bipy	2.13	-1.84
					phen	4.09	-3.43
N-methyl-*S*-tryptophan	CH_3	H	C_8H_7N	H	bipy	0.72	+0.69
S-tyrosine	H	H	C_6H_4OH	H	bipy	1.23	-0.51
α-methyl-*S*-tyrosine	H	H	C_6H_4OH	CH_3	bipy	2.33	-2.10

¶ Refers to the equation: Δ-{Ru(diimine)(aa)}$^+$ $\overset{h\nu}{\rightleftarrows}$ Λ-{Ru(diimine)(aa)}$^+$

† Completely selective towards Δ isomer as defined in §

§

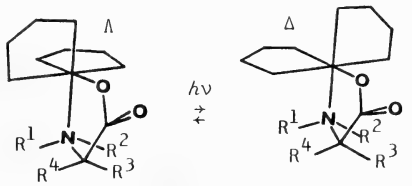


TABLE 2

General Discriminatory Effects of Substitutional Changes in Δ,Λ-{Ru(diimine)$_2$(*S*-aa)}$^+$ Systems

Change	*Effect*
Replace *bipy* by *phen*	Increased Λ preference (0.5-1.7 kJmol^{-1})
Substitute bulky α-side chain	Increased Λ preference ($\sim$1-2 kJmol^{-1})
Replace α-methine H by CH_3 group	Increased Λ preference ($\sim$1.6 kJmol^{-1})
N-methyl substitution	Increased Δ preference ($\sim$1 - 3 kJmol^{-1})*
N-phenyl substitution	Complete Δ selectivity*

(* At equilibrium isomers with the N-substituent *anti* to the α- side chain only are observed)

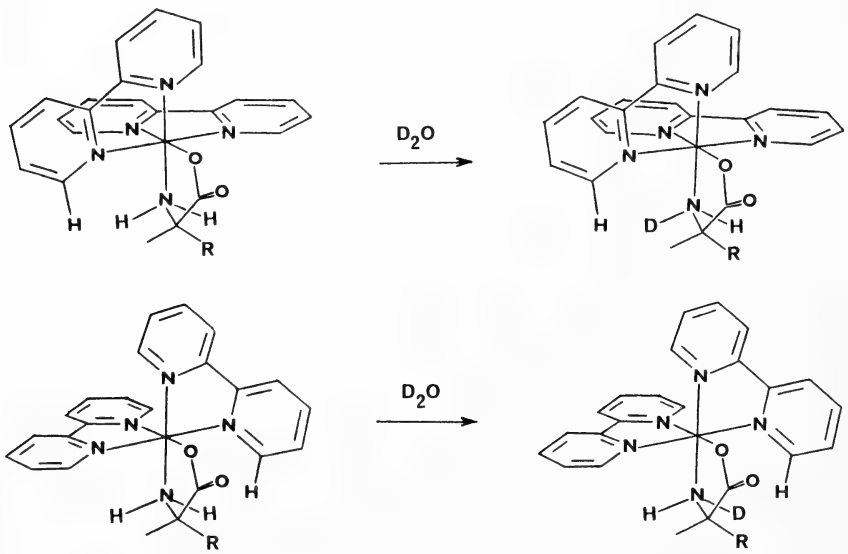


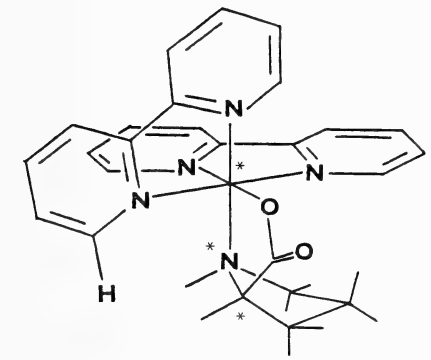
Figure 8 Examples of stereoselective proton-deuteron exchange processes in [Ru(bipy)$_2$(S-aa)]$^{n+}$ complexes.

bipyridine ligands by phenanthroline. Even more significant effects are obtained with the N-substituted acids. The magnitude of each of these effects is represented by the chiral discrimination energy values (ΔG^o) shown in the Table. In general these energy terms are additive, so that the thermodynamic consequence of any substitutional change in the molecules may be predicted empirically. The general effects of these changes are summarised in Table 2, which may be used for this predictive purpose.

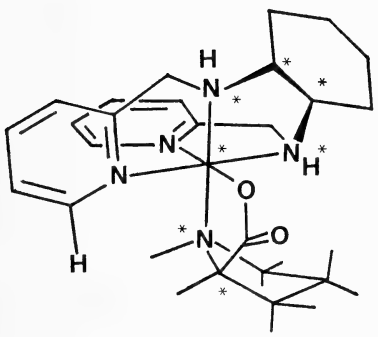
Stereoselective Proton-Deuteron Exchange

If any of these amino acid complexes are dissolved in D_2O and stored in the dark an interesting exchange reaction involving the amine protons may be detected using proton-NMR spectroscopy (Vagg and Williams, 1983; 1984). In an unsubstituted amino acid complex of this type the two protons of the coordinated amine group are in different steric and electronic environments. This non-equivalence is reflected in the observed rates of exchange of

these protons with deuterons of the solvent. This exchange reaction is stereoselective with those amine protons feeling the repulsive and electronic deshielding influences of the diimine groups being by far the more labile. As a result stable species are obtained in which each amine nitrogen atom becomes chiral due to mono-substitution of deuterium. In the lambda isomers the chirality induced at the N atom has an R designation; in the delta propellers an S absolute configuration is induced (Vagg and Williams, 1984). These exchange reactions are demonstrated in some detail in Figure 8. Corresponding differences in these proton exchange rates are observed also in complexes of the mono-N-substituted acids (Stark et al, 1984).



Λ-[M(bipy)$_2$(*S*-pro)]$^{n+}$



Λ-β_2-[M(*R*,*R*-picchxn)(*S*-pro)]$^{n+}$

Fig. 9 The similar steric environments of coordinated S-proline in the complex cations Λ-[M(bipy)$_2$(S-pro)]$^{n+}$ and Λ-β_2-[M(R,R-picchxn)(S-pro)]$^{n+}$. Asterisks show atomic chiral centres in the molecules.

The Use of Asymmetric Tetradentates

Both the steric preferences and stereoselective exchange reactions described above are caused by the imposed asymmetric environment of the coordinated amino acids in these species. This is due specifically to the close proximity to the acid of one pyridyl group of a diimine molecule. This environment may be reproduced by the use of other ligands, in particular tetradentates containing a terminal pyridyl group and designed to incorporate this structural feature. As a result discriminatory coordination and stereoselective reactions should be observable if the two diimine ligands were to be replaced by such a tetradentate molecule. An example of this structural analogy is shown in Figure 9.

This change could have the advantage of providing a more rigid molecular topology, if desired, with associated increased control over these discriminating effects. The chirality of the metal atom may be determined by the use of a stereospecific asymmetric tetradentate. Conversely, any photo-lability in the chelates could be used to determine discrimination energy differences between the several topologies that are possible if a flexible ligand of this type is chosen.

The work now has been extended in order to determine the magnitude of the chiral discriminations that are possible with these tetradentate systems. Recently the relatively inflexible ligand N,N'-di(2-picolyl)-1R,2R-diaminocyclohexane (picchxn) has been shown to demonstrate stereospecific coordinating properties, which includes the ability to selectively coordinate S-proline and not R-proline (Goodwin, Vagg and Williams, 1984). This selectivity is seen as having a steric cause, as demonstrated by Fig. 9, with interaction of the terminal pyridyl group of picchxn and the side chain of R-proline being too severe to allow coordination. The asymmetric nature of the ligand specifically determines the metal propeller configuration as lambda. The asymmetric environment that this ligand provides also has been utilized so as to allow a highly stereoselective synthesis of R-alanine through reaction of a coordinated prochiral bidentate reagent (Goodwin, Mulqi, Williams and Vagg, 1984).

The ability to quantify and compare experimentally those factors which influence chiral discriminations in these systems should facilitate the design of ligands for several specific stereochemical purposes. This includes the design of resolving agents in general, stereoselective control of coordination to allow resolution of racemic ligand mixtures and the control of the stereoselectivity of reactions at coordinated molecules similar to the R-alanine synthesis mentioned above.

ACKNOWLEDGEMENT

The original research described in the latter part of this Address has been carried out in collaboration with two other members of this Society. They are Dr P.A.Williams of University College, Cardiff and Dr F.S. Stephens of Macquarie University whose contributions are acknowledged here.

REFERENCES

Alworth, W.A., 1972. STEREOCHEMISTRY AND ITS APPLICATION IN BIOLOGY. Wiley-Interscience, New York, 311pp.

Barnes, G.T., Backhouse, J.R., Dwyer, F.P., and Gyarfas, E.C., 1955. Studies of the Diastereoisomeric Effect. Part II. The Redox Potentials of the Systems (+) and (-) Tris-2:2'-Dipyridyl Osmium II /(+) and (-), Tris-2:2'-Dipyridyl Osmium III in the Presence of Optically Active Electrolytes. J. Proc. Roy. Soc. N.S.W., **89**, 151-156.

Bentley, R., 1982. Chemical Methods for the Investigation of Stereochemical Problems in Biology, in STEREOCHEMISTRY, pp. 49-112 . Tamm, Ch. (Ed.). Elsevier Biomedical Press, Amsterdam.

Bernal, I., Hamilton, W.C. and Ricci, J.S., 1972. SYMMETRY: A STEREOSCOPIC GUIDE FOR CHEMISTS. W.H.Freeman & Co., San Francisco, 180pp.

Cahn, R.S., Ingold, C.K. and Prelog, V., 1956. Specification of Asymmetrical Configuration in Organic Chemistry. Experientia, **12**, 81-94.

Cahn, R.S., Ingold, C.K. and Prelog, V., 1966. Specification of Molecular Chirality. Angew. Chem. Int. Ed. Engl., **5**, 385-415.

Cotton, F.A., 1971. CHEMICAL APPLICATIONS OF GROUP THEORY. 2nd edn. Wiley-Interscience, New York, 386pp.

Craig, D.P., 1974. Optical Activity and Energy Discrimination. Proc. Roy. Aust. Chem. Inst., **41**, 1-5 .

Craig, D.P. and Mellor, D.P., 1976. Discriminating Interactions Between Chiral Molecules. Topics in Current Chem., **63**, 1-48.

Craig, D.P., 1980. Interactions Between Chiral Molecules: Discriminating Interactions, in HORIZONS IN QUANTUM CHEMISTRY, pp. 123-140. K.Fukui and B.Pullman (Eds.). D.Reigel Publ. Co., Holland.

Dwyer, F.P., 1959. The Future of Inorganic Chemistry in Biology. Aust. J. Sci., **22**, 240-247.

Dwyer, F.P., Gyarfas, E.C. and O'Dwyer, M.F., 1955. Studies of the Diastereoisomeric Effect. Part I. The Solubilities of (+) and (-) Tris-1:10-phenanthroline Ruthenium II Perchlorates in Solutions Containing Optically Active Ions. J. Proc. Roy. Soc. N.S.W., **89**, 146-150.

Feiser, L.F. and Feiser, M., 1944. ORGANIC CHEMISTRY. D.C.Heath and Co., Boston, pp. 253-256.

Gillard, R.D. and Mitchell, P.R., 1970. The Absolute Configuration of Transition Metal Complexes. Structure and Bonding, **7**, 46-86.

Goodwin, T.J., Mulqi, M.W., Williams, P.A. and Vagg, R.S., -----. Chiral Metal Complexes. 18. A Highly Stereoselective Synthesis of Alanine. Inorg. Chim. Acta (In press).

Goodwin, T.J., Vagg, R.S. and Williams, P.A., 1984. Chiral Metal Complexes. 15. Alanine and Proline Complexes of [N,N'-Di(2-picolyl)-1R,2R-diaminocyclohexane]cobalt(III). J. Proc. Roy. Soc. N.S.W., **117**, 1-6.

Goodwin, T.J., Williams, P.A., Stephens, F.S. and Vagg, R.S., 1984. Chiral Metal Complexes. 12. Chiroptical, ^{1}H NMR and Crystallographic Studies of the Diastereoisomers Λ and Δ -[Ru(diimine)$_2$(S-threonine)]$^+$ and Their S-Allothreonine Analogues. Inorg. Chim. Acta, **88**, 179-195.

Goodwin, T.J., Williams, P.A. and Vagg, R.S., 1984. Steric Interactions in some Complexes of General Form [Ru(diimine)$_2$(S-aminoacidate)]$^{n+}$. Inorg. Chim. Acta, **83**, 1-4.

Kalyanasundaram, K., 1982. Photophysics, Photochemistry and Solar Energy Conversion with Tris(bipyridyl)ruthenium(II) and its Analogues. Coord. Chem. Rev., **46**, 159-244.

Kauffman, G.B., 1974. Alfred Werner's Research on Optically Active Coordination Compounds. Coord. Chem. Rev., **12**, 105-149.

Kushi, Y., Kuramoto, M. and Yoneda, H., 1976. Structural Study of Optical Resolution. I. The Crystal Structure of tris(ethylenediamine)cobalt(III) Bromide d-Tartrate Pentahydrate. Chem. Lett., 135-136.

Lambert, J.B., Shurvell, H.F., Verbit, L., Cooks, R.G. and Stout, G.H., 1976. ORGANIC STRUCTURAL ANALYSIS, pp. 317-332. Macmillan Publ. Co. Inc., New York.

Mason, S.F., 1982. MOLECULAR OPTICAL ACTIVITY AND THE CHIRAL DISCRIMINATIONS. Cambridge Univ. Press, Cambridge.

Mead, C.A., 1974. Symmetry and Chirality. Topics in Current Chem., **49**, 1-88.

Mellor, D.P., 1970. Dwyer's Contribution to Coordination Chemistry, Proc. Roy. Aust. Chem. Inst., **37**, 199-208.

Saito, Y., 1979. INORGANIC MOLECULAR DISSYMMETRY. Springer-Verlag, Berlin, 167pp.

Shulman, A. and Dwyer, F.P., 1964. Metal Chelates in Biological Systems, in CHELATING AGENTS AND METAL CHELATES, pp. 383-439. Mellor, D.P. and Dwyer, F.P. (eds.). Academic Press, New York.

Shunikov, A.V. and Koptsik, V.A., 1974. SYMMETRY IN SCIENCE AND ART. Plenum Press, New York, 420pp.

Stark, A.G., Stephens, F.S., Vagg, R.S. and Williams, P.A., 1984. Unpublished results.

Stephens, F.S., Vagg, R.S. and Williams, P.A., 1983. Chiral Metal Complexes. 7. A Comparison of the Structures of the Two Diastereoisomeric Forms of $[Ru(bipy)_2$L-alanine$]ClO_4.0.5H_2O$ as Determined by Single Crystal X-Ray Diffraction. Inorg. Chim. Acta., **72**, 253-261.

Testa, B., 1982. The Geometry of Molecules: Basic Principles and Nomenclatures, in STEREOCHEMISTRY, pp. 1-47. Tamm, Ch. (Ed.). Elsevier Biomedical Press, Amsterdam.

Vagg, R.S. and Williams, P.A., 1981a. Chiral Metal Complexes. 1. Photochemical Inversion in Ternary Ru(II) Complexes of Diimines and L-Tryptophane. Inorg. Chim. Acta, **51**, 61-65.

Vagg, R.S. and Williams, P.A., 1981b. Chiral Metal Complexes. 2. Light-Catalysed Diastereoisomeric Equilibration in Aqueous Solutions of cis-$[Ru(phen)_2$(L-serine)$]^+$ and its 2,2'-Bypyridyl Analogue. Inorg. Chim. Acta, **52**, 69-72.

Vagg, R.S. and Williams, P.A., 1982a. Chiral Metal Complexes. 3. The pH-Controlled Equilibrium of Diastereoisomeric Pairs of Ternary Cis-Ru(II)-Diimine Complexes with L-Glutamic Acid. Inorg. Chim. Acta, **58**, 101-105.

Vagg, R.S. and Williams, P.A., 1982b. Chiral Metal Complexes. 5. Sources of Chiral Discrimination in Aqueous Solutions of the Complexes Δ, Λ-$[Ru(diimine)_2$(L-aspartate$)]^0$ and their Conjugate Acids. Inorg. Chim. Acta, **63**, 133-140.

Vagg, R.S. and Williams, P.A., 1983. Chiral Metal Complexes. 4. Stereoselective Deuterium Exchange at the Coordinated NH_2 Group of L-Alanine. Inorg. Chem., **22**, 355-357.

Vagg, R.S. and Williams, P.A., 1984. Unpublished results.

School of Chemistry
Macquarie University
North Ryde, N.S.W. 2113

(Manuscript received 28.8.84)

Journal and Proceedings, Royal Society of New South Wales, Vol. 117, pp. 113-117, 1984
ISSN 0035-9173/84/020113 — 05 $4.00/1

Oligocene and Miocene Volcanic Rocks and Quartzose Sediments of the Southern Tablelands, New South Wales: Definitions of Stratigraphic Units

PAUL BISHOP

ABSTRACT. Tertiary volcanic rocks and associated quartzose sediments in the Goulburn-Crookwell area of N.S.W. have been important in determining the Cainozoic history of this portion of the Southeast Australian highlands. Six units, the Bevendale Basalt, Hollymount Formation, Wheeo Basalt, Divide Basalt, Bannister Basalt and Pomeroy Basalt, are defined in order to aid discussion of the evolution of this area.

INTRODUCTION

Widespread Tertiary basaltic vulcanism in eastern Australia (Wellman and McDougall, 1974a, 1974b) has left many areas with basalt cappings which have been used to reconstruct drainage and tectonic histories (Wellman, 1979, 1980; Bishop and Young, 1980; Young, 1981; Bishop, 1982). The basaltic rocks and associated sediments are critical to our understanding of the drainage and tectonic histories of this portion of the highlands because these materials have clear relationships with former drainage systems, unlike other supposed evidence of ancient drainage systems, such as incised meanders and anomalous tributary junctions (Bishop, 1982).

On the portion of the Southern Tablelands of New South Wales (N.S.W.) described here, vulcanism occurred in the Eocene and the Late Oligocene/Early Miocene (Fig. 1). The remnants of this vulcanism, which constitute part of O'Reilly and Griffin's (1984) Grabben Gullen Province, consist of either narrow lava residuals marking former river valleys and overlying silicified and unsilicified quartzose fluvial sediments, or broader sheets of the volcanic rocks. The latter are generally found closer to the continental drainage and owe their present sheet geometry to low relief at the divide at the time of extrusion and, possibly, to greater preservation due to distance from the major trunk streams.

Away from the divide the volcanics now generally occur as sinuous hill-top remnants, and with their associated sediments (Fig. 1) have been important in deciphering the landscape history of the area (Bishop, 1984a, 1984b, in press, in prep.; Bishop and Young, 1980; Bishop *et al.*, in prep.; Young, 1981). Most importantly, they demonstrate stability of the divide in both the horizontal and vertical dimensions, at least in the Neogene and possibly throughout the Cainozoic. This has clear implications for models of highland uplift (e.g. Wellman, 1979; Jones and Veevers, 1982) and for plate tectonic models of the evolution of the southeastern margin of Australia (e.g. Herbert, 1980; Ollier, 1982). As well, identification of silicified *Nothofagus* wood found in association with the Early Miocene lavas in this area constitutes one of the few Miocene identifications of macrofossils of this genus which so dominates the Tertiary palynological record (Bishop and Bamber, in prep.).

The following Late Oligocene and Early Miocene units are defined to facilitate forthcoming discussions of the landscape and vegetation history of this area of the Australian divide: Bevendale Basalt, Hollymount Formation, Wheeo Basalt, Divide Basalt, Bannister Basalt and Pomeroy Basalt. The lithological descriptions of the Bevendale, Wheeo, Divide and Bannister Basalts are based on four, four, one and eleven major element analyses respectively (S.Y. O'Reilly, pers. comm.; P. Morris, pers. comm.) and these descriptions use the terminology recently proposed formally by Le Maitre (1984). The Pomeroy Basalt has not been analysed and the lithological description is general only, without implying that it is distinctive from any of the analysed samples. Potassium-argon age determinations for the basaltic rocks here described are presented by Wellman and McDougall (1974), Young and Bishop (1980) and Bishop *et al.* (in prep.) and are shown on Figure 1. All units defined here are undeformed and crop out in the central part of the Goulburn 1:250 000 sheet area (SI 55-12); all grid references are to the Australian Map Grid.

DEFINITION OF STRATIGRAPHIC NAMES

BEVENDALE BASALT - New name

Derivation of Name: Hamlet of Bevendale; grid reference 94507650.

Distribution: The unit occurs in discontinuous, narrow, linear outcrops which run from Mt Martin to Dalton and from Dalton to the junction of the Lachlan and Crookwell Rivers.

Type section: The unit is poorly exposed and many outcrops are quite weathered. The type section is weathered but is the thickest exposure. It is designated as a 70 m section on a tributary gully to Jerrara Creek, 3 km N.W. of Mullengrove hamlet, from 96808445 (bottom) to 96458415 (top). The top is the sub-aerial upper surface of the lava and the base is the lowest lava overlying Ordovician phyllite.

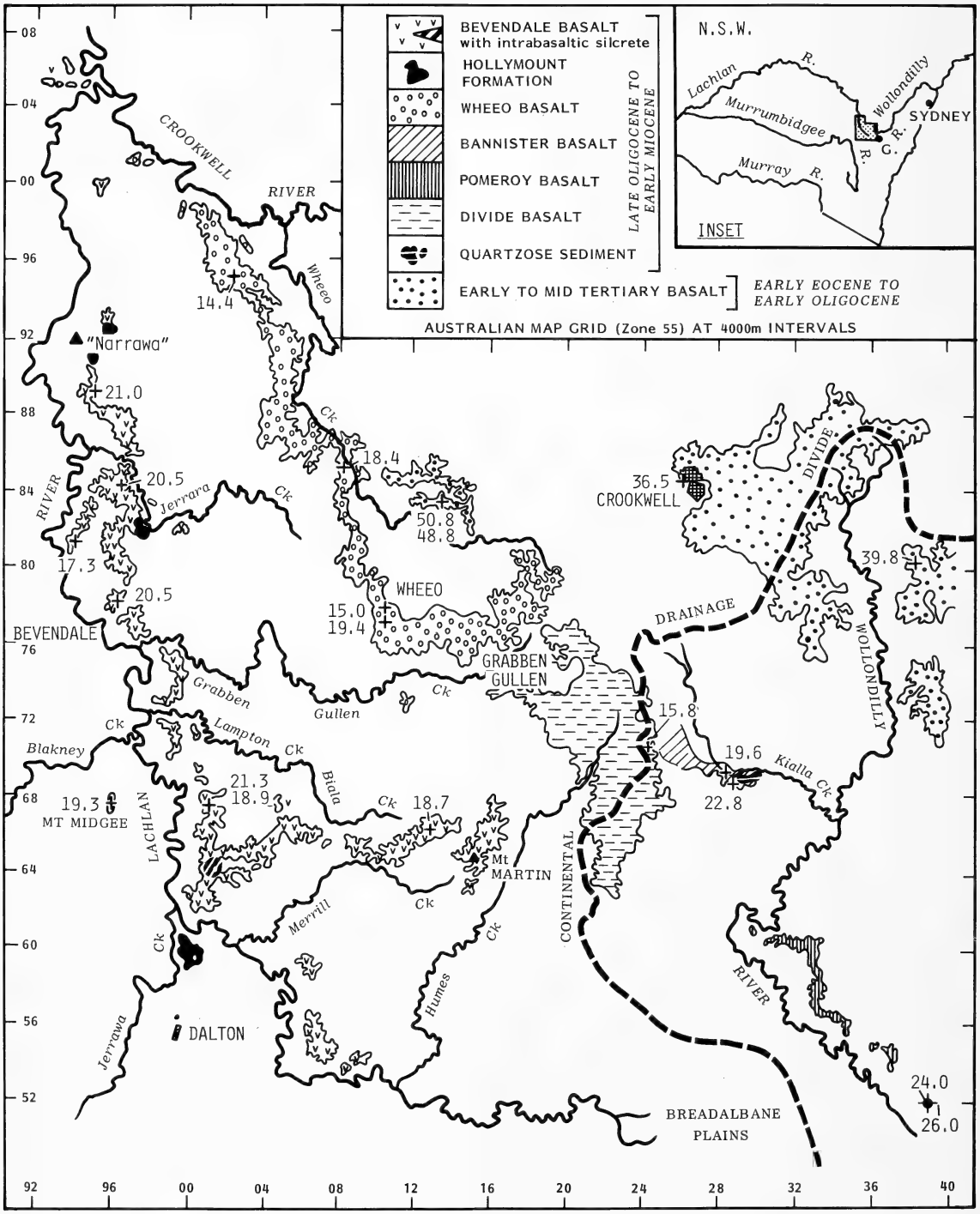


Fig. 1. Tertiary geology of the upper Lachlan and upper Wollondilly valleys, N.S.W., showing the location of the rock units named in this paper. The symbol, +21.5, indicates the location and age (m.y.) of a K-Ar age determination. The Inset shows the location of the main map and of Goulburn (G.).

Lithology: The unit consists of fine-grained to porphyritic olivine basalt and trachybasalt; occasionally it is coarse-grained (doleritic). Generally, it is columnar, but massive, hackly and platy forms are all present. Palagonitized flow-foot breccia incorporating black, glassy basalt, basaltic glass and palagonite crops out at grid reference 01106360 (Bishop, in press). Individual flows are rarely distinguishable on field criteria, but breaks between flows are occasionally marked by interbedded silcrete (silicified quartzose fluvial sediment).

Thickness: Range 20 to 100 m.

Relationships: Unit conformably overlies Hollymount Formation or, where this formation is absent, disconformably overlies either granitic rocks of the Palaeozoic Wyangala Batholith or undifferentiated Ordovician phyllites. The base of the unit is occasionally marked by either a prominent ironstone band or a grey clay which is very weathered basalt. Upper boundary is the sub-aerial upper surface of the basalt.

HOLLYMOUNT FORMATION - New name

Derivation of Name: "Hollymount" property; grid reference 96957865.

Distribution: Unit is exposed discontinuously between Gunning and Narrawa in association with the overlying Bevendale Basalt.

Type section: Ten metres of semi-lithified quartzose sand, granules and gravel exposed beneath the Bevendale Basalt in a cutting on Paddy's Creek at grid reference 97257945. The base is identified by very coarse quartz cobbles (up to 30 cm intermediate axis) and the top by medium to fine sands abruptly overlain by Bevendale Basalt.

Lithology: The Hollymount Formation generally consists of fine sand to coarse cobbles of white quartz, in orange-brown clayey sand matrix; it is massive to cross-bedded. It also occurs in a silicified form as benches of massive sand and cobble silcrete, some of which contain silicified wood and leaf fragments. At grid reference 97487698 the Hollymount Formation consists of laminated white sandy clay.

Thickness: Range 1 to 15 m.

Relationships: The unit disconformably overlies undifferentiated Ordovician phyllites as a channel-fill and is generally conformably overlain by Bevendale Basalt. The Hollymount Formation crops out beneath and topographically above the Bevendale Basalt and represents quartzose fluvial sediment which was deposited prior to extrusion of the lavas of the Bevendale Basalt. The outcrops of the Hollymount Formation now found topographically above the Bevendale Basalt were probably covered by the basalt which has since been removed by erosion.

WHEEO BASALT - New name

Derivation of Name: Wheeo locality; grid reference 10507855.

Distribution: The unit occurs continuously from the vicinity of Grabben Gullen through Wheeo to the Crookwell River.

Type section: The unit is very poorly exposed and generally very weathered. The type section is a 90 m section in a tributary gully to the Crookwell River, north of "Table Top" homestead, from 02259720 (bottom) to 02059695 (top). The top is the sub-aerial upper surface of the preserved lavas and the base is a weathered amygdaloidal grey hackly basaltic rock overlying very weathered gneissic granite and grus.

Lithology: Olivine basanite and basalt; columnar in good exposures with colonnade columns overlain by entablature (e.g. 00959750).

Thickness: Up to 110 m.

Relationships: The unit disconformably overlies granitic rocks of the Palaeozoic Wyangala Batholith or undifferentiated Ordovician phyllites, or conformably overlies sporadically occurring quartzose to mixed quartzose and lithic ?fluvial sand and gravel which are presumed to be essentially contemporaneous with the basalt. Upper boundary is the sub-aerial upper surface of the basalt. On field criteria, the Wheeo Basalt may have been formerly continuous with the Divide Basalt.

DIVIDE BASALT - New name

Derivation of Name: The Great Dividing Range, south of Crookwell; grid reference 24507080.

Distribution: the unit is exposed over about 40 km^2 along the crest of the Australian continental drainage divide in the central portion of the Goulburn 1:250 000 Sheet area.

Type section: The unit is very poorly exposed and the type section is designated as 60 m of fine-grained and doleritic basaltic volcanic rocks cropping out on the divide from 24657090 (bottom) to 24557120 (top).

Lithology: Uniform fine-grained to porphyritic basanite; doleritic and brecciated basaltic rocks.

Thickness: About 60 m.

Relationships: Disconformably overlies undifferentiated Ordovician phyllite. Upper surface is the sub-aerial upper surface of the basalt. On field criteria, this basalt may have been formerly continuous with the Wheeo Basalt.

BANNISTER BASALT - New name

Derivation of Name: Bannister locality, grid reference 28086895.

Distribution: The unit crops out as a 5 km tongue of superimposed basaltic lavas in the headwaters of Kialla Creek, a tributary to the Wollondilly River.

Type section: This is designated as a 28 m section in a tributary gully to Kialla Creek, from 28856885 (bottom) to 28856880 (top). From the

base, the section consists of 20 m of basaltic rocks, 1 m of silcrete and a further 7 m of basaltic rocks. The base of the unit is identified by brownish-grey very weathered basalt overlying orange-brown quartzose sediment.

Lithology: Porphyritic, even-grained and glassy basanite with local high concentrations of ultramafic xenoliths. Columnar, platy, hackly and massive forms are all common. The unit contains minor interbeds of inter-flow silcrete and black pedal clays with quartz granules.

Thickness: 30 to 40 m.

Relationships: The Bannister Basalt discontinuously and conformably overlies one metre of essentially contemporaneous orange-brown, cross-bedded quartzose sand and granules. Where this sub-basaltic sand is absent, the unit disconformably overlies undifferentiated Ordovician phyllite. The upper boundary is the sub-aerial upper surface of the basalt.

POMEROY BASALT - New name

Derivation of Name: "Pomeroy" property, grid reference 29206235.

Distribution: The Pomeroy Basalt occurs as a sinuous line (15 km long) of hilltop basalt on north bank of Wollondilly River, west of Goulburn.

Type section: This basalt is extremely poorly exposed and there appears to be *in situ* outcrop at only one locality, on the upper surface of the basalt at grid reference 31956038. This is designated as the type locality. A second locality, Quarry Hill (grid reference 38805193), is a K-Ar dating locality of Young and Bishop (1980) and while no *in situ* basalt crops out here, there is a clear relationship with the underlying *in situ* silcrete.

Lithology: Porphyritic to even-grained olivine basaltic rock.

Thickness: Maximum of 40 m, generally about 30 m.

Relationships: The unit either i) disconformably overlies undifferentiated Ordovician fine-grained metasediments or granitic rocks of the Wologorong Batholith, or ii) conformably overlies silicified quartzose fluvial sediments (silcrete).

ACKNOWLEDGMENTS

The author thanks Associate Professor M.A.J. Williams and Dr J.G. Jones, School of Earth Sciences, Macquarie University, for their advice and supervision of the Ph.D. Thesis on which this note draws. Geochemical analyses by Dr S.Y. O'Reilly and Dr P. Morris are also greatly appreciated. Financial support of field work was supplied by the Department of Geography, University of Sydney.

REFERENCES

Bishop, P., 1982. Stability or change: a review of ideas on ancient drainage in eastern New South Wales. *Aust. Geogr., 15*(4), 219-30.

Bishop, P., 1984a. Stability or change: the late Cainozoic history of the Wollondilly and Upper Lachlan Rivers. *Ph.D. Thesis, Macquarie Univ.* (unpubl.).

Bishop, P., 1984b. Modern and ancient rates of erosion of central eastern N.S.W. and their implications, *in* DRAINAGE BASIN EROSION AND SEDIMENTATION, pp. 35-42. R.J. Loughran (Compiler). Dept of Geography, University of Newcastle, N.S.W. and Soil Conservation Service of N.S.W.

Bishop, P., ----. Early Miocene flow-foot breccia from the Upper Lachlan valley, N.S.W.: characteristics and significance. *Aust. J. Eth. Sci.* (In press).

Bishop, P., ----. Low rates of denudation of eastern Australia during the late Mesozoic and Cenozoic: Testing models of increased continental denudation in the late Tertiary. *Geology* (in prep.).

Bishop, P. and Bamber, K.R., ----. Early Miocene *Nothofagus* and Myrtaceae silicified wood from the upper Lachlan valley, N.S.W. *Alcheringa* (in prep.).

Bishop, P. and Young, R.W., 1980. Discussion: On the Cainozoic uplift of the southeastern Australian highland. *J. Geol. Soc. Aust. 27*(1), 117-9.

Bishop, P., Young, R.W. and McDougall, I., ----. Stream profile change and longterm landscape evolution - Early Miocene and modern rivers of the east Australian highland crest, New South Wales. *J. Geol.* (in prep.).

Herbert, C., 1980. A tectonic origin for south-east Australian streams. *Rec. Aust. Bur. Miner. Resour. Geol. Geophys. 67*, 34-5.

Jones, J.G. and Veevers, J.J., 1982. A Cainozoic history of Australia's Southeast Highlands. *J. Geol. Soc. Aust. 29*(1), 1-12.

Le Maitre, R.W., 1984. A proposal by the IUGS Subcommission on the Systematics of Igneous Rocks for a chemical classification of volcanic rocks based on total alkali silica (TAS) diagram. *Aust. J. Eth. Sci. 31*(1), 243-9.

Ollier, C.D., 1982. The Great Escarpment of eastern Australia: tectonic and geomorphic significance. *J. Geol. Soc. Aust. 29*(1), 13-23.

O'Reilly, S.Y. and Griffin, W.L., 1984. Sr isotope heterogeneity in primitive basaltic rocks, southeastern Australia. *Contrib. Mineral. Petrol. 87*, 220-30.

Wellman, P., 1979. On the Cainozoic uplift of the southeastern Australian highland. *J. Geol. Soc. Aust. 26*(1), 1-9.

Wellman, P., 1980. Reply: On the Cainozoic uplift of the southeastern Australian highland. *J. Geol. Soc. Aust. 27*(1), 119.

Wellman, P. and McDougall, I., 1974a. Potassium-argon ages on the Cainozoic volcanic rocks of New South Wales. *J. Geol. Soc. Aust. 21*(3), 247-72.

Wellman, P. and McDougall, I., 1974b. Cainozoic igneous activity in eastern Australia. *Tectonophysics 23*, 49-65.

Young, R.W., 1981. Denudational history of the south-central uplands of New South Wales. *Aust. Geog. 15*(2), 77-88.

Young, R.W. and Bishop, P., 1981. Potassium -argon ages on Cainozoic volcanic rocks in the Crookwell-Goulburn area, New South Wales. *Search 11*(10), 340-1.

Department of Geography
University of Sydney
N.S.W. 2006.

(Communicated by R.A.L. Osborne)

(Manuscript received 3.11.1984)

Journal and Proceedings, Royal Society of New South Wales, Vol. 117, pp. 119-127, 1984
ISSN 0035-9173/84/020119 — 09 $4.00/1

A Biographical Register of Members of the Australian Philosophical Society (1850-55) and the Philosophical Society of New South Wales (1856-66). Part I

A. A. Day and J. A. F. Day

INTRODUCTION

In recent years the Royal Society of New South Wales has received an increasing flow of requests for information about past members and enquiries as to whether a person was a member at some time. These enquiries have come from members of the Society as well as from non-members and outside organisations. Approximately two-thirds of the enquiries are known or appear to be connected with genealogical research (which has recently achieved amazing popularity). The other one-third of enquiries arises from various research projects in the history of Australian science and technology.

The lack of any co-ordinated membership lists for the Royal's predecessor societies, which operated in the middle of the nineteenth century, considerably impeded answering enquiries relating to that period. To rectify the deficiency seemed imperative; impetus was added by the preparations in hand to ensure an appropriate place for science in the forthcoming Bicentenary celebrations.

We therefore undertook the compilation of as complete a list of members of the Royal Society of New South Wales' two main antecedents as could be managed after the lapse of one and a quarter centuries. Mere compilation of a list of names would have been relatively straight-forward, but would not have answered such obvious questions as: what kind of work did these men (for they were all men) do?; how old were they?; what strands of colonial society did they represent?, and so on. Thus we hoped to gain some appreciation of the human aspects of scientific endeavour in nineteenth century Australia, and of lay awareness of and reaction to such activity. Our list in its final form, with brief biographical data attached, proved to be of such length that we felt it was best published in two parts in order not to take up too much space in any one issue of the Society's Journal. In Part II we complete our list and append some brief analyses to suggest answers to the questions posed above.

BRIEF HISTORY OF THE SOCIETIES

Prior to the gold rushes in the 1850s the colony of New South Wales, consisting of the present New South Wales, Victoria and Queensland, had a small European population distributed over a huge area. There appears to have been little demand for organised meetings for intellectual recreation. Such demand as existed was, it seems, satisfied by societies with a practical orientation such as horticulture and agriculture. The Australian (subscription) Library in Sydney doubtless also fulfilled some of the desire for information. In 1821 Governor Sir Thomas Brisbane, a scientist in his own right, founded an "Australasian Philosophical Society" with a band of (strictly male) associates, but there is no record of it having survived after his departure from the colony late in 1825. In 1850 two former members of the 1821 Society, Sir Charles Nicholson and Dr. Henry Grattan Douglass, with some enthusiastic friends and the encouragement of Governor Sir Charles Fitz Roy, essayed another attempt to provide an intellectual forum of a scientific-technological kind by founding the "Philosophical Society of Australia". This society prospered to the extent of gaining upwards of sixty (still strictly male) members, only to be struck a nearly mortal blow after its first birthday by the discovery of payable gold and the vast changes in eastern Australian society that resulted therefrom.

Upon his arrival in Sydney in 1855 Governor Sir William Denison quickly initiated a personal project to get a scientific society going as soon as possible. He was an engineer, and had taken an active part in the affairs of the Royal Society of Van Diemen's Land while he was Governor in Hobart. Denison got together some of the councillors of the Australian Society and arranged with them to found a new society to be called the "Philosophical Society of New South Wales". This society took over the remaining members and funds of the Australian Philosophical Society, and in 1856 got off to a spectacular start by enrolling ninety-two new members at its second meeting. The time was indeed ripe for the founding of such a body for the population had grown enormously and quite a few both new and old Australians had acquired the fashionable interest in matters scientific and technical. Interests were astonishingly diverse, covering the field sciences, the ever-popular astronomy, and a great variety of practical activities. There were even persons interested in mathematical topics of some complexity. The annual Conversaziones of the Philosophical Society drew large crowds, displays of photography being a major attraction. The Philosophical Society functioned successfully for almost a decade. Eventually it began to languish, and in November 1865 the members resolved to seek a Royal charter to adopt the name "Royal Society of New South Wales". With the assistance of Governor Sir John Young, this was achieved, and the Royal Society commenced in 1867.

Long-standing members of the Society, such as Professor J. Smith and the Rev.W.B. Clarke, reviewing these events later, consistently regarded the sequence of societies - the "1850", "1856" and "1867" societies - as but one Society under different names (Clarke, 1867, Smith, 1881). A detailed transcription of the minutes of the societies and events recounted above was published by Maiden (1918).

CONSTRUCTION OF THE MEMBERSHIP LIST

Unfortunately the registration of members in the several societies including the first few years of the Royal, appears to have been haphazard. In some cases full names and addresses were recorded, in other instances only a surname was recorded, perhaps identified by 'Dr.' in a few relevent instances. Although there are a few references in the minutes of meetings to membership lists, none

seems to have survived for the 1821, 1850 and 1856 societies, neither have treasurer's lists of membership subscriptions received. The 1867-68 lists for the Royal, published in its Transactions, have curious omissions and inconsistencies. (Some names appear in the published list before the person was elected, and many of those elected in 1869 were omitted from the 1869 list.) We found to our dismay that in attempting his large transcription of the Philosophical Society's minutes (Maiden, 1918) Maiden had unfortunately omitted some names or parts of names, and had undoubtedly misread a few others:

Errors and Omissions in Maiden's Transcriptions, J. and P., vol. 52

p.264: Robertson, James Junr. should read Johnson, James Junr.;
p.267: Francis, C.E. should read Francis Bell, C.E;
p.268: J.J. Rodd should read J.S. Rodd;
—— Elliott; A. Knipe should read Elliott A. Knipe;
Rev. Dr. Hortzel should read Rev. Dr. Hoelzel;
p.285, line 5: The name of W.S. Creeny should be added, and Hillyer should read Hellyer;
p.288: Mr. J. Glaister should read Mr. T. Glaister;
p.291: Charles Wall, Esq. should read Charles Watt Esq.;
p.298: Thomas Baker should read Thomas Barker;
p.272: John F. Hill should read John F. Hilly;
p.282: Francis Gisbourn should read Francis Gisborne;
p.263: Add: —— Keane, Esq., Newcastle.

In order to gain some biographical appreciation of each person we have consulted a wide variety of sources, both printed and verbal. Where a biography of a person has already been published we include a reference to it, or to the latest if more than one has appeared. Our debt to the Australian Dictionary of Biography, its many authors and its editors is considerable. But we did feel a little surprise at the omission by the "ADB" of persons we considered might have merited inclusion. Some of the people proved particularly tantalising and difficult to track down. With some we must confess failure to elicit any significant details. We should naturally be very grateful to receive any supplementary information, and also corrections, for we recognise that some of our identifications (indicated within square brackets) may be mistaken. Because most of the records of the Societies are hand-written the possibility of mis-interpretation of names and initials has been guarded against as much as possible. Capital I, J, T and S posed a particular problem, and some of the other similar letters, including F and P, and H, W and M also presented difficulties at times.

ACKNOWLEDGEMENTS

We are grateful to many people for assistance with information, including the Archivists of Sydney County Council, Sydney City Council and The University of Sydney. The project would have been impossible without access to the resources of the State Library of New South Wales, the Mitchell Library, the University of Sydney Library, the Registrar-General and the Supreme Court of New South Wales.

REFERENCES

CLARKE, W.B., 1867. Inaugural Address to the Royal Society of New South Wales. Sydney Morning Herald, 10 July, 1867.

MAIDEN, J.H., 1918. A contribution to a history of the Royal Society of New South Wales. *J. and Proc. Roy. Soc. NSW.*, *52*, 215-361.

SMITH, J., 1882. Anniversary Address to the Royal Society of New South Wales. *J. and Proc. Roy. Soc. NSW.*, *15*, 1-12.

ABBREVIATIONS AND SYMBOLS USED IN THE LIST OF MEMBERS

ADB	Australian Dictionary of Biography. Melbourne Univ. Press.
APS	Australian Philosophical Society (with period of membership when known).
B.	Date and place of birth, when known
Connolly	Connolly, C.N., 1983. Biographical Register of the New South Wales Parliament, 1856-1901. ANU Press.
D.	Date and Place of death, when known.
Ford	Ford, E., 1976. Bibliography of Australian Medicine. Sydney Univ. Press.
J & P	Journal and Proceedings, Royal Society of N.S.W.
JRAHS	Journal and Proceedings, Royal Australian Historical Society.
LSN	Linnean Society of New South Wales.
PLSN	Proceedings, Linnean Society of N.S.W.
PSA	Philosophical Society of Australasia.
PSN	Philosophical Society of New South Wales (with date of admission to membership).
RSN	Royal Society of New South Wales (with period of membership).
Tanre	Tanre, Con. The Mechanical Eye. Sydney.
?	Used where doubt exists or to suggest a possible identification.
[ ]	Enclose suggested identifications of names when these were not given in full in the original records.

LIST OF MEMBERS

AARON, Dr Isaac
PSN 13.6.1856; paper, 10.9.1856, "On sanitary reform," printed SMH 12.9.1856, p.5; SMSA 1:193. Medical practitioner; B. 1804, Birmingham, Eng.; d. 17.8.1877, Sydney. See ADB 1:1.

A'BECKETT, Dr Arthur Martin
APS 1850, committee 1850. PSN ?. Surgeon to Benevolent Asylum, examiner in medicine, Univ. of Sydney; FRCS; Aust. Museum cttee 1852-55; MLC 1856-60. B. c1812; d. 23.5.1871, Sydney. See Connolly p. 2-3, Heaton p.1.

ADAMS, Philip Francis
PSN 5.10.1864. RSN 1867-1901. Surveyor-general 1868-1887; astronomer and vigneron. B. 1828, Suffolk, Eng.; d. 22.6.1901, Liverpool, NSW. See ADB 3:16.

ALLAN, Andrew
PSN 13.6.1856. RSN 1867-69. ?Auctioneer in Sydney (SSD) and possibly pioneer landholder Goulburn and Illawarra districts.

ALLEN, George
APS ?. PSN probably a foundation member. RSN 1867-77. Solicitor and businessman. B. 1800, London, Eng.; d. 3.11.1877, Sydney. See ADB 1:5-7, Connolly p.6-7.

ALLEN, George Wigram
APS ?. PSN probably a foundation member. RSN 1867-85. Solicitor, businessman, politician and benefactor. B. 16.5.1824, Sydney; d. 23.7.1885, Sydney. See ADB 3:24-25, Connolly p.7, J&P 20:7-8.

ALLEN, William Bell
PSN 8.9.1858. Soap and candle manufacturer and politician. B. 1812, Ireland; d. 5.12.1869, Waverley, NSW. See ADB 3:25-26, Connolly p.7.

ALLEYNE, Dr Haynes Gibbes
PSN 13.8.1856. Medical practitioner; a local pioneer of chloroform anaesthesia, 1852. B. c1815, Barbados; d. 9.9.1882, Sydney. See ADB 3:26.

ALLWOOD, Rev. Robert
PSN 13.6.1856. RSN 1867-91. Anglican clergyman and educationist. B. 24.9.1803, Jamaica; d. 27.10.1891, Edgecliff, NSW. See ADB 1:10-11, Mennell p.8.

ARMITAGE, Rev. Frederick
PSN 13.8.1856. Anglican clergyman, educationist and philologist; left NSW c1863. B. 1.5.1827, Yorkshire, Eng.; d. 21.12.1906, Hampshire, Eng. See ADB 3:49.

ARNHEIM, Edward H[enry], von
PSN 21.9.1859. Surveyor, private, then govt. 1864-79. D. 20.8.1879, Sydney.

ASHDOWN, Archibald
PSN 8.7.1857. RSN 1867-69. Manager Australasian Sugar Co., Sydney, c1847-1854; wholesale and retail ironmonger; accountant NSW railways 1867-70. D. 11.6.1898, Woollahra, NSW.

ASHWIN, Rev. Forster
PSN 13.6.1856. Anglican clergyman, incumbent of Holy Trinity (Garrison) Church, Millers Point, 1855-58; B.A. B. c1824; d. 1912, Norfolk, Eng.

BADDELEY, Lieut.-col. [Frederick Henry]
APS 1850. British army engineer, commanding officer of detachment of Royal Engineers, Sydney, 1850-56, retired 10.6.1856 honorary major-general.

[BARKER, Rt. Rev. Frederic]
PSN 13.6.1856. Anglican bishop of Sydney. B. 17.3.1808, Derbyshire, Eng,; d. 6.4.1882, Italy. See ADB 3:90-94.

BARKER, Thomas
PSN 17.8.1864. Flour miller and tweed manufacturer; MLA 1856-57. B. 1799, London, Eng.; d. 1875, Bringelly, NSW. See Connolly p. 14-15.

BARLOW, A[ndrew] H[enry]
PSN 8.7.1857. Bank officer and Qld. politician. B. Aug. 1836, Essex, Eng.; d. 29.3.1915, Toowong, Qld. See ADB 7:177.

BARLOW, James
PSN 8.10.1856. Engineer, Australian Gas Light Co., Sydney. D. 1873, Sydney. See A.G.L. Co. History, 1837-1897, p. 29.

BARNET, James [Johnstone]
PSN 5.7.1865. RSN 1867-69. NSW Govt. Architect 1865-90; Australian Museum trustee 1866-90. See ADB 3:100-102.

BARNEY, Lieut.-col. George
APS c1850. PSN 1856-62. Military engineer and administrator; Austn. Museum Cttee 1849. B. 19.5.1792, England; d. 16.4.1862, Willoughby, NSW. See ADB 1:60-61.

BEAZLEY, Mr.
PSN 10.6.1857. This person may be either: Beazley, Rev. Joseph. Congregational minister in Sydney, 1850s. D. 9.1.1899, Kent, Eng.; OR Beazeley, Alexander. Civil engineer.

BEDFORD, [Dr] Edward [Samuel Pickard]
PSN 17.8.1864, treasurer 1865-66. Paper: 12.9.1866, "Remarks on the support of the young of marsupial animals in the pouch". RSN 1867-76, treasurer 1867-74. FRCSE; surgeon, public servant and politician. Founder of St Mary's Hospital, Hobart. B. 1809, London, Eng.; d. 24.2.1876, Sydney. See ADB 3:128-9; J&P 10:11-12.

BELISARIO, [Dr] J[ohn]
PSN 8.7.1857. RSN 1868-1899. Dental surgeon; pioneered the use of ether anaesthetic in Sydney. B. 1820, Cheltenham, Eng.; d. 17.6.1900, Waverley, NSW. See ADB 3:132-3.

BELL, Charles jnr.
PSN 18.7.1860. Draftsman. D. 1869?

BELL, Edward
PSN 13.6.1856. RSN 1867-1871? C.E., M.Inst. C.E.; city engineer, Sydney Municipal Council, 1851-1870.

BELL, Francis
PSN 13.8.1856. C.E., M.Inst.C.E.; city engineer Sydney Municipal Council, 1870?-1878. D. 7.9.1879, Petersham, NSW.

BELL, Dr William
PSN 9.9.1857. RSN 1869-1871. M.D., MRCS.; medical practitioner and coroner at Carcoar, Campbelltown-Picton and Sydney. B. c1815; d. 1871. See Ford p.29.

BENBOW, George [Frederick]
PSN 13.6.1856. Solicitor.

BENNETT, William Christopher
PSN 13.6.1856, council 1864-65. Civil engineer and surveyor; commissioner for roads, NSW, 1862-1889. B. 4.7.1824, Dublin, Ire.; d. 29.9.1889, North Sydney. See ADB 3:142-3; Mennell p. 35-6.

BENSUSAN, Samuel Levi
PSN 11.5.1859. RSN 1869-1905. Merchant and mining promoter. B. c1827; d. Nov. 1917, England. See J&P 52:3.

BERNCASTLE, Dr [Julius]
PSN 13.6.1856. Papers: 11.11.1857, "On the use and abuse of tobacco"; 11.6.1862, "On the cave temples of India" printed in Trans. PSN: 178-191; 17.6.1863, " On snake-bites and their antidotes", printed in Trans. PSN: 191-6. LRCSE, MRCP; physician and surgeon; founder and surgeon of the Sydney Ophthalmic Inst. for Cure of Diseases of the Eye. See Lancet 1871 (1):215; Ford p.29.

BERRY, Alexander
PSA 5.12.1821. APS 1850, council 1850. PSN 1856. RSN 1867-1872. Merchant and pastoralist. B. 30.11.1781, Fife, Scot.; d. 17.9.1873, Crows Nest, NSW. See ADB 1:92-95; J&P 55:xxxiii.

BLAKE, James E[lliott]
PSN 9.9.1857, microsc. cttee. Merchant.

BLAND, Dr William
APS 1850, council 1850. PSN 8.10.1856. Papers: 8.7.1857, "On sanitary reform" printed in SMSA 2:41 & 55; 8.6.1859, "On atmotic navigation". MRCS; medical practitioner. See ADB 1:112-5; Ford pp.39-41.

BONAR, Andrew
PSN 13.8.1856, microsc. cttee. Magistrate.

BOULTON, E[dward] B.
PSN 13.6.1856. B. c1821; d. 1895.

BOWMAN, Dr [Robert]
PSN 10.9.1856. M.D., MRCS; medical practitioner. B. 2.2.1830, Richmond, NSW.; d. 23.5.1872, Richmond, NSW. See ADB 3: 208-9, Ford p.44.

BOYD, Dr [Sprott]
PSN 8.6.1859, council 1861, microsc, cttee. RSN 1867-1877. LRCSE, M.D.Edin., MRCS; surgeon; medical referee for the AMP Society, examiner for Faculty of Med., Univ. of Sydney; Aust. Museum Trustee 1862-65. D.15.4.1902, England.

BRADRIDGE, Thomas H[enry]
PSN 14.7.1858. Chief draftsman Sydney City Council, 1860s and 1870s. D. 10.11.1878, Woollahra, NSW. See J&P 13:xl.

BRADRIDGE, W[illiam]
PSN 13.6.1856. Builder and architect. B. c1803; d. 18.2.1868, Redfern, NSW.

BRANSBY, Spencer [Lasinby]
PSN 9.12.1857. Surveyor. B. c1817; d. 1874, Moruya, NSW.

BROADHURST, Edward
PSN visitor, exhibited photographs 19.12.1850. Barrister and politician. B. 2.7.1810, Bath, Eng.; d.7.4.1883, Sydney. See ADB 3:234-6; Connolly p.29.

BROWN, George William
PSN 10.12.1856. Pioneer settler in Dapto district. B. c1811.

BROWN, Henry J[oseph]
PSN 13.6.1856. RSN 1876-1914. Solicitor to A.A. Co., etc.; chairman Newcastle School of Arts. B. c1834; d. 12.8.1914, Newcastle, NSW. See J&P 49:5-6; PLS 40:viii.

BROWN, Joseph Lyne
PSN 13.6.1856. Photographer. See Tanre.

BROWNE, Capt. H[utchinson] H[othershall]
PSN13.6.1856, microsc. cttee. Water police superintendent, magistrate, agent for immigration, director of Sydney Infirmary, chairman of directors of Aust. General Assurance Co.

BUCKLAND, Dr
APS 1850.

BURDEKIN, Marshall
PSN 13.6.1856. Barrister and politician. B, 11.4.1837; d. 10.11.1886, Eng. See ADB 3: 297-8; Connolly p.38.

BURGON, Joseph
PSN 8.6.1859, microsc. cttee. Surgeon. D. 8.3.1864.

BURNELL, H[enry] C[lay]
PSN 12.11.1856. Magistrate.

CAMPBELL, O[swald] R[ose]
PSN 13.6.1856. Artist. B. 1820, Jersey, C.I.; d. 18.3.1887, Melbourne, Vic. See ADB 3:346-347.

CAPE, W[illiam] T[imothy]
APS 1850. PSN 1856. School headmaster; founder Sydney Mechanics School of Arts. B. 25.10.1806, Surrey, Eng.; d. 14.6.1863, London, Eng. See ADB 1:209-210; Connolly p.48.

CAPPER, Mr
APS 1851; paper, 21.5.1851, "On the applicability of machinery as a means of saving hand labour", printed in SMH 23.5.1851, p.2.

CATLETT, A[rthur] L[iddiard]
PSN 13.6.1856. Public servant. D. 30.5.1876, Woollahra, NSW.

CATLETT, W[illiam] H[enry]
PSN 13.6.1856; apptd Assistant Secretary 12.5.1858, resigned 30.4.1877 (from RSN). Professional secretary. D. 26.3.1903, Burwood, NSW.

CLARKE, J[acob] R[ichard]
PSN c1859. Exhibitor at conversaziones 19.12.1859, 19.12.1860, 16.5.1862, 17.12.1862, of photographs and engravings. Music publisher and bookseller. B. 1822, Taunton, Eng.; d. 12.7.1898, Waterloo, NSW. See ADB 3:414-5.

CLARKE, Samuel
PSN 17.12.1862.

CLARKE, Rev. William Branwhite
APS 1850, council 1850. PSN 1856, vice-pres. 1858-1866, microsc. cttee. RSN 1867-1878. Papers to PSN: 8.9.1858, "On the present state of the supply of the ores of mercury" SMSA 2:157-161, 170-173; 20.11.1861, "On some recent geological discoveries in Australasia, and the correlation of the Australian formations with those of Europe"; 7.9.1864, "Remarks on [Mr. J. Tebbutt's paper 'On Australian Storms']", Trans. PSN: 165-177; 10.5.1865, "On the transmutation of rocks in Australasia", Trans. PSN: 267-308. Anglican clergyman and geologist; Aust. Museum Cttee/Trustees 1840-1874, chairman 1867. See Grainger, E., 1982, 'The Remarkable Reverend Clarke'; ADB 3:420-422; J&P 13:4-23. JRAHS 30(1944).

COLLETT, W[illiam] R.
PSN 13.8.1856. Surveyor of roads, NSW Govt, Commissioner 1861-62. D. c1863. See 'The Road-makers' (DMR) pp. 44, 45.

COMRIE, James
PSN 13.6.1856. RSN 1876-1901. Pastoralist and politician. D. 2.11.1902, Kurrajong, NSW. See Connolly p.60.

COOPER, Sir Daniel
PSN ?. Exhibited photographs 8.12.1858; exhibited black lead 16.5.1860. Merchant, philanthropist and politician; senator Univ. of Sydney 1857-61. B. 1.7.1821, Lancashire, Eng.; d. 5.7.1902, London, Eng. See ADB 3:452; Connolly p. 62.

COOPER, Lieut.-col. [Leonard] Morse
PSN 13.6.1856. British army officer.

COWLISHAW, James
PSN 13.6.1856. Architect and publisher. B. 19.12.1834, Sydney; d. 25.7.1929, Brisbane, Qld. See ADB 3:475; Mennell p.108.

COWPER, Sir Charles
APS 1850, council 1850. PSN ?. Politician. B. 26.4.1807, Lancashire, Eng.; d. 19.10.1875, London, Eng. See ADB 3:475-9; Connolly p.65.

COX, Dr James [Charles]
PSN 8.6.1859, council 1866, microsc cttee. RSN 1867-1897. Papers: 9.7.1862, "On the Wambeyan Caves" in Trans. PSN: 197-204; 3.10.1866, "On the genus Trigonia...". M.D.; medical practitioner; the second medical student at Sydney Infirmary 1850-52; shell collector ; Aust. Museum Trustee 1865-1912, chairman 1889-90, president 1890-1912. B. 21.7.1834, Mulgoa, NSW; d. 29.9.1912, Mosman, NSW. See ADB 3:482-484; Strahan p.41.

CRACKNELL, Edward [Charles]
PSN 7.6.1865. RSN 1867-1893. Electrical engineer; superintendent of telegraphs, NSW; torpedo expert. B. 1831, Kent, Eng.; d. 14.1.1893, Woollahra, NSW. See ADB 3:488-9; J&P 27:3.

CREENY, W[illiam] S[pence]
PSN 18.7.1860. Schoolmaster. D. 1867, St Leonards, NSW.

DAINTREY, Edwin
PSN 13.8.1856. Solicitor. D. 30.10.1887, Randwick, NSW. See PLS 2(n.s.):1089.

DALTON, Edwin
PSN 14.10.1857. Artist and photographer. With his brother Edward exhibited at conversaziones 19.12.1860, 12.12.1861, 17.12.1862. See Tanre.

DANGAR, Henry Cary
PSN 19.9.1860. Barrister, sportsman and politician. B. 4.6.1830, Port Stephens, NSW; d. 25.4,1917, Potts Point, NSW. See ADB 4:14-15; Connolly p.75.

DAVISON, Simpson
PSN 13.6.1856. Pastoralist and gold pioneer. B. c1816, Yorkshire, Eng.; d. 1861, Tarban Creek, NSW. See his book "The discovery and geognosy of gold deposits in Australia", 1860.

DAWSON, Alexander
PSN 17.10.1860. Colonial Architect of NSW 1856-1862.

DEFFELL, George [Hibbert]
PSN 13.6.1856. RSN 1867-1893. Barrister and judge. B. 30.5.1819, London, Eng.; d. 21.9.1895, Tunbridge Wells, Eng. See ADB 4:39; Mennell p.125.

DENISON, A[lfred Robert]
PSN 13.6.1856. Private secretary to Sir William Denison. Fellow of founding Senate of the University of Sydney 24.12.1850; Trustee of Aust. Museum 1858-1860. B. 1816; d.1887.

DENISON, His Excellency Sir William Thomas
PSN 9.5.1856 (founder), president 1856-1860, microsc. cttee. Papers: 9.5.1856, "Development of the railway system in England, with suggestions as to its application to the Colony of NSW", SMSA 1:8-9; 12.11.1856, "On irrigation", SMSA 1:140; 8.7.1857, "On the moon's rotation", SMSA 1:43-44; 12.8.1857, "On railways", SMSA 1:62-68; 8.9.1858, "On the filtration of water through sand", SMSA 2:73-74; 19.9.1860, "On bridge-building". KCB. Governor General. B. 3.5.1804, London, Eng.; d. 19.1.1871, Surrey, Eng. See ADB 4:46-53; Trans RSN 6:3.

DICK, Alexander
PSN 13.10.1858, council 1863. Solicitor, politician and public servant. Examiner of land titles. D. 2.8.1867, London, Eng. See Connolly p.85.

DOCKER, Joseph
PSN 14.7.1858, council 1864. RSN 1867-1872. Surgeon and politician. MLC 1856-61, 1863-1884. B. 1802, London, Eng.; d. 9.12.1884, Sydney, NSW. See ADB 4:79-80; Connolly p.89.

DOUGLASS, Henry Grattan
PSA 1821-?. APS 1850-1855, secretary 1850-55. PSN 1856, secretary 1855-57, council 1858. MD, MRIA. Physician; physician to the Sydney Infirmary, Benevolent Asylum, and Female Refuge; member of the senate of the University of Sydney 1856-1865. B. 1790, Dublin, Ire.; d. 1.12.1865, Sydney, NSW. ADB 1:314-316; J&P 55:xxxv; Connolly p.93.

DRUITT, Thomas
PSN 13.8.1856. Anglican clergyman and schoolmaster. B.21.10.1817, Dorset, Eng.; d. 30.12.1891, Petersham, NSW. See ADB 4:103.

DRURY, Edward Robert
PSN 10.6.1857. Paper: 13.10.1858, "Currency and Banking in NSW", SMSA 2:96-103. Banker and soldier; colonel in Qld. Defence Forces. B. 1832, Brussels, Belg.; d. 3.2.1896, Qld. See ADB 4:104-5; Mennell p.140.

DYER, Joseph
PSN 10.6.1857. Publisher. Editor of the Sydney Magazine of Science and Art.

EDE, Frederick Charles
PSN 8.10.1858. Merchant. B. c1806; d. 1869.

ELOUIS, Charles
PSN 13.6.1856. Superintendent of the Bullion Office, Royal Branch Mint, Sydney 1854-68; Deputy Master, Royal Branch Mint, Sydney 1868-?. D. 8.6.1911, Sydney.

EWEN, R[obert] Rupert
PSN 13.6.1856. Clerk. Appointed Clerk, Dept. of Works 23.4.1860; Railways Dept. 1864.

FALKNER, George
PSN 8.7.1857, microsc. cttee.

FELTON, Thomas
PSN 10.9.1856. Artist and photographer.

FITZ ROY, Sir Charles Augustus
APS 1850-1854, patron 1850-54. Governor-general. B.10.6.1796, Derbyshire, Eng.; d. 16.2.1858, Piccadilly, Eng. See ADB 1:384-389.

FLANAGHAN, Roderick
PSN 17.10.1860-1861. Journalist. Wrote "History of New South Wales", London. 2 vols (1860). B. 1.4.1828, Ire; d. 13.3.1861, Eng. See ADB 4:185-186.

FLAVELLE, John
PSN 11.7.1856. RSN 1867-91. Optician, jeweller and watchmaker (Flavelle Brothers and Co.); director of Sydney Infirmary 1866-1875. B. 1816; d. 23.6.1899, Sydney.

FORD, William
PSN 16.5.1866. Printer and publisher.

FORTESCUE, Dr [George]
PSN 17.6.1863. RSN 1867-85. MB, FRCS. Medical practitioner. Honorary surgeon Sydney Infirmary 1870-1874; trustee Australian Museum 1869-1875. D. 1.6.1885. See J&P 20:7.

FOSS, Ambrose
PSN 13.8.1856. Chemist, druggist and dental surgeon. B. c1803, Eng.; d. 4.5.1862, Sydney.

FOULIS, Dr [John]
PSN 8.7.1857. MD. Surgeon. Examiner in medicine for the University of Sydney 1866; appointed assistant surgeon, Suburban Battalion Volunteer Corps 9.9.1861. D. 21.3.1870, Sydney.

FOWLER, Francis E[dmund Town]
PSN 13.6.1856. Journalist and author. Wrote for Monitor and SMH. B. 1833, London, Eng.; d. 22.8.1863, London, Eng. See ADB 4:208-9.

FOWLES, Joseph
PSN 13.6.1856. Artist. D. 25.6.1878, Forest Lodge, NSW. See ADB 1:409-10.

FOX, Capt. Henry T[homas]
PSN 13.6.1856. Master mariner and marine surveyor. B. 31.5.1819, Eng.; d. 29.4.1891, Burwood, NSW. See ADB 4:210.

FREEMAN, James
PSN 10.6.1857, paper: 8.12.1858, "On the progress of photography", printed SMSA 2:136-141. Photographer. B. 1814, Bath, Eng.; d. 22.10.1870, Eng. See ADB 4:220.

FULLERTON, James
PSN 13.6.1856. DD. Presbyterian clergyman. B. 11.1.1807, Ire.; d. 3.7.1886, Sydney, NSW. See ADB 4:224.

GARDINER, Martin
PSN 17.12.1862. RSN 1867-1872. Papers to PSN: 9.7.1862, "Geometrical researches, in four papers, comprising numerous new theorems and porisms and complete solutions to celebrated problems", Trans. PSN: 61-126; 12.8.1863, "On the correct scientific method of forming railway curves, &c"; 17.8.1864, "On improved analytic geometry", Trans. PSN: 61-126; 2.11.1864, "A complete solution of celebrated problem", Trans. PSN: 61-126. Civil engineer and mathematician.

GARRAN, Dr Andrew
PSN 13.6.1856. RSN 2.9.1868-1901. LL.D. Journalist and politician. MLC 1887-1892, 1895-1901; Assistant Editor SMH 1856-1873, Editor 1873-1885. B. 15.11.1825, London, Eng.; d. 6.6.1901, Darlinghurst, NSW. See ADB 4:233, Connolly p.119-120.

GEE, Mr
APS 1850-? Paper, 2.9.1850 on "Dyes" - fixing dyes from Hino bark on woollen cloth. He also exhibited skins of the wild cat suitable for export.

GISBORNE, Francis
PSN: Visiting speaker, paper: 21.9.1859: "On telegraphic communication with England" also exhibited samples of submarine cables. American; an advocate for trans-oceanic communication cables especially those laid and operated by the company owned by his brother Lionel and himself.

GLAISTER, T[homas Skelton]
PSN 15.5.1861. American photographer active in Sydney in 1860s. See Tanre.

GOODLET, John [Hay]
PSN 19.12.1859. RSN 1867-1913. Timber merchant and benefactor. B. 22.3.1835, Scotland; d. 13.1.1914, Sydney, NSW. See ADB 4:263-264; J&P 48:2.

GRACE, Charles
PSN 13.6.1856. ?Builder and architect. ? D. 21.3.1895, Dubbo.

GRAY, Samuel [William]
PSN 20.11.1861. RSN 1867-1871. Farmer and politician. MLA 1859-64, 1874-1880, 1882-1885 Kiama, Illawarra and Richmond, resp. B. 1823, Armagh, Ire; d. 19.4.1889, Woollahra, NSW. See Connolly p.130.

GREENUP, Dr [Richard]
APS ?. PSN ?. Paper: 9.6.1858, "Abridgement of a book of papers relating to the history and practice of vaccination presented to Parliament by command of the Queen"; MD Camb.; Medical practitioner. B. 15.3.1803, Halifax, Eng.; d. 17.7.1866, Sydney.

GRUNDY, Francis H[enry]
PSN 10.9.1856. RSN 1875-1879. Civil engineer and surveyor.

HAES, Frank
PSN 13.6.1856, microsc. cttee. Paper: 9.9.1857, "On the waxed-paper process of photography". English photographer. See Tanre.

HAGAEN, Mr.
PSN ?. 19.12.1860, exhibited a debusscope at conversazione.

HALE, Thomas
PSN 7.12.1864. RSN 12.7.1871-1881. Coal mine owner and merchant. Opened coal mine at Bellambi, NSW, 1857.

HANSON, William
PSN 13.6.1856. Government Printer 1854-1859; alderman on first Randwick municipal council, 1859.

HART, James
PSN 13.8.1856. Solicitor and politician. MLA 1858-1872 various electorates. B. 1825; d. 1873, Sydney. See MOLA p.94.

HAWKINS, Capt. [John Summerfield] RE
PSN 13.6.1856. Military engineer, railway surveyor and commissioner. Appointed Railway Commissioner 11.3.1856, resigned Mar 1857.

HAY, John
PSN ?. RSN 1874-1892. KCMG. Pastoralist and politician. B. 26.6.1816, Aberdeenshire, Scot.; d. 20.1.1892, Rose Bay, NSW. See ADB 4:361-2; Connolly p.141; PLS 34:2.

HAYDON, Henry
PSN 13.6.1856. ? B. c1821; d. 1856, Camperdown, NSW.

HELLYER, William
PSN 18.7.1860. Solicitor. D. 8.1.1885, Sydney, NSW.

HERBORN, Ernest [William Lewis]
PSN 13.5.1857. Surveyor to the AA Co. Licensed Surveyor 1.2.1858. D. 6.10.1909, Burwood, NSW.

HETZER, William
PSN 11.6.1862. On 19.12.1860, exhibited portraits, slides, views, stereos at conversazione. German photographer, arr. NSW 1850. See Tanre.

HICKEY, Edwin [Augustus]
APS 1850-?. Papers: 2.9.1850, paper on Cedar occurrence in NSW, publ. in SMH 26.10.1850; Jan. 1851, paper on Viticulture in NSW, SMH 18.1.1851. Viticulturalist in Hunter Valley and wine merchant; second pres. of Hunter Valley Vignerons Assocn.

HILL, Ed[ward] S[mith]
PSN 13.7.1859-1866, council 1864. RSN 1867-1880 (Life member). Magistrate. CMZS; Trustee of the Aust. Museum 1862-1880. Appointed a Commissioner of the Philadelphia International and Melbourne Intercolonial Exhibitions Commission, NSW, 27.4.1875. D. 1880, probably Rose Bay, NSW.

HILL, Francis [William]
PSN 12.11.1862. Public Servant. Apptd clerk, GPO, Sydney 1.1.1855; Chief Clerk of the Letter Branch, NSW Post Office 1.7.1863; Superintendent of the Money Order Office, PMG Dept. 26.6.1865; Controller of the NSW Govt Savings Bank 1.9.71. D. 2.10.1895, Sydney.

HILL, Richard
PSN 12.11.1862. Pastoralist and politician. MLC 1880-1895. B. 22.9.1810, Sydney; d. 19.8.1895, Bent St., Sydney. See ADB 4:400-1; MOLA p.99; Connolly p.146-7.

HILLY, John F[rederick]
PSN 12.8.1857. Architect. B. c1810; d. 3.9.1883, Potts Point, NSW.

HODGSON, Sir Arthur
PSN 12.8.1857. Pastoralist and politician. Superintendent A.A. Co. 1856-1861; MLA NSW 1858-1860; MLA Qld 1868-1869. Knighted 1886. B. 29.6.1818 Hertfordshire, Eng.; d. 24.12.1902, Stratford on Avon, Eng. See ADB 4:405-6; MOLA p.99-100; Connolly p.148.

HODGSON, Charles J.
PSN 13.6.1856. Assayer.

HOELZEL, Rev. [Herman] ("Dr")
PSN 10.9.1856. Rabbi. Hebrew minister in Tasmania 1853-1856, and Sydney 1856-1858. See Porush, J. Aust. Jewish Hist. Soc. 2:172-200 (1945).

HOLDEN, George Kenyon
APS 1850, council 1850. PSN, council 1856-1857. RSN 1867-1872. Solicitor and politician. MLC 1856-1861, 1861-1863. B. 1808, Eng.; d. 16.4.1874, Darlinghurst, NSW. See ADB 4:410; Connolly p.150.

HOLROYD, [Arthur Todd]
APS 1850. RSN 1876-1887. MD, Edin., MB Camb. Physician, explorer and jurist. B. 1.12.1806, London, Eng.; d. 15.6.1887, Merrylands, NSW. See ADB 4:411-12; J&P 22:1; Connolly p.152.

HOLT, Thomas
PSN 13.8.1856. RSN 1867-1882. Merchant, financier and politician. MLC 1868-1883. B. 14.11.1811, Yorkshire, Eng.; d. 5.9.1888, Kent, Eng. See ADB 4:414; Connolly p.152-3.

HOOD, Thomas H[ood Cockburn]
PSN 10.9.1856. Pastoralist and politician. MLC 1856-1861.

HOOPER, Walter
PSN 13.6.1856. Roads superintendent, Roads Branch NSW Dept. of Internal Communication 1864.

HOSE, Rev. Henry Judge
PSN 8.7.1857, council 1859, 1860. Anglican clergyman and mathematics teacher. Warden of St. Paul's College 1856-61. B. 1826, London; d. 16.6.1883, Bishops Stortford, Eng. See ADB 4:428.

HOUSTON, Dr. Hugh
PSN 13.6.1856. Surgeon. Resident surgeon and apothecary Sydney Infirmary and Dispensary 1845-1866. D. 21.8.1866, Sydney. See Stokes, p.12.

HOUSTON, Dr. [William]
PSN 10.9.1856. Surgeon. D. 28.12.1862, Sydney.

HUNT, Robert
PSN 13.6.1856. RSN 1878-1892. Apptd practical chemist and first clerk of the Bullion Office, Royal Branch Mint, Sydney 9.7.1853; Aust. Museum trustee 1879-1892. B. 1830; d. 27.9.1892, Sydney. See J&P 27:4.

HUNTLEY, Alfred [R]
PSN 8.10.1856. Engineer to Australian Gas Light Company. D. 12.7.1868, Tarban Point.

INGELOW, [George] K[ilgour]
PSN 17.12.1862. Bank manager. Arr. NSW c1857; Manager Oriental Bank; a director of Sydney Infirmary 1860-61. D. 10.8.1865, Sydney.

ISAACS, Robert MacIntosh
PSN 13.8.1856. Barrister and politician. MLC 1857-1861, MLA Yass Plains 1865. B. 1814, West Indies; d. 26.3.1876, Darlinghurst. See ADB 4:464; Connolly, p165-6.

ISRAEL, Moss
PSN 10.9.1856. Soap and candle manufacturer (Cowan and Israel).

JACKSON, Fred[erick] J[ames]
PSN 11.6.1862. Secretary. Secretary European Assurance Society 1860s; apptd Sub-Lieutenant, Volunteer Naval Brigade 1869. D. 22.5.1923, Darling Point, NSW.

JAMES, William
PSN ?. Meeting 16.5.1858, exhibited a model of a revolving battery; meeting 17.12.1862, exhibited a new invention for scuttling ships.

JENKINS, R[ichard] L[ewis]
PSN 9.9.1857. RSN 1876 -1883. MRCS. Physician and pastoralist. MLA 1858-59. B. 1815; d. 1883, Brisbane, Qld. See Connolly p.168.

JEVONS, W[illiam] Stanley
PSN 13.6.1856. Papers: 8.7.1857, "On a new sun-gauge" printed in SMSA 1:58-62; 9.12.1857, "On the formation of clouds" SMSA 1:163-176. Assayer, amateur pioneer meteorologist and photographer. Assayer at Royal Branch Mint, Sydney 1854-1859. Returned to England 1859. B. 1835, Liverpool, Eng.; d. Aug. 1882, Eng. (drowned). See ADB 4:480-481.

JOHNSON, Richard
PSN 13.6.1856. Solicitor.

JOSEPHSON, Joshua Frey
PSN 11.6.1862, treasurer 1864. RSN 1867-1892. Businessman and judge. MLA Braidwood 1864-1869; district court judge 1869-70. B. 1815, Hamburg; d. 26.1.1892, Bellevue Hill, NSW. See ADB 4:492-493; Connolly p.175.

KEENE, W[illiam]
PSN 13.6.1856. Paper: 6.9.1865, "On the geological position of the petroleum coal". Exhibits: 19.12.1860, geological sections of Singleton and Yass, etc; 12.11.1862, an instrument for testing quality of coal mine air. Government Examiner of Coalfields. B. 1795, Bath, Eng.; d. 2.2.1872, Raymond Terrace, NSW. See ADB 5:5-6; Heaton p.104; Trans RSN 9:2.

KEMP, Charles
PSN 9.6.1858. Journalist and politician; proprietor of Sydney Morning Herald 1841-1853. B. 2.6.1813, London, Eng.; d. 25.8.1864, Sydney. See ADB 2:40-42; Connolly p,178-9.

KEMP, Rev. C[harles] C[ampbell]
PSN 8.6.1859. Anglican clergyman, incumbent of Camperdown, Sydney. B. c1811; d. 16.6.1874, Port Macquarie, NSW.

KING, Rev. R[obert] L[ethbridge]
APS 1850-?, council 1850-?. Anglican clergyman; trustee Australian Museum 1848-1858. See ADB 5:30-31.

KINLOCH, John [(jnr)]
PSN 15.5.1861. RSN 1877-1883. Schoolmaster. Matriculated Sydney Univ. 1852, MA. 1859, esquire bedell 1866-1897; ran various schools in Sydney, incl. Hurlstone, 1874-80. B. c1832, Dublin, Ire.; d. 9.4.1897, Sydney.

KIRCHNER, William (Wilhelm)
PSN 9.6.1858. Merchant; organised immigration of German farm labourers.

KNAPP, Edward J[ames] H[owes] jnr
PSN 13.6.1856. Surveyor.

KNIPE, Elliott A.
PSN 10,9,1856. Registrar and accountant, Royal Branch Mint, Sydney, 1853-63.

KREFFT, [Johann Ludwig Gerard]
PSN 9.7.1862, council 1863, 1865-66. RSN 1867-1874. Papers to PSN: 10.9.1862, "On the vertebrated animals of the lower Murray and Darling; their habits, economy and geographical distribution" Trans PSN: 1-33; 27.5.1863, "On reptiles found near Sydney, with remarks upon their

habits and geographical range" Trans PSN: 34-60; 17.9.1863, "On the vertebrated animals of the lower Murray ...," second paper, Trans PSN: 1-33; 11.11.1863, "Description of a new fish from the Hawkesbury"; 2.8.1865, On the manners and customs of the natives of the lower Murray and Darling"; 1.8.1866, "On the dentition of Thylacoleo carnifex"; 7.11.1866, "On the classification of the small marsupial insectivora". Curator and secretary Australian Museum 1860-74. B. 17.2.1830, Germany; d. 19.2.1881, Randwick, NSW. See ADB 5:42-44.

LANE, Henry
PSN 20.6.1860. Public servant in Colonial treasury; under-secretary for finance and trade 1856-73. B. c1818; d. 9.9.1873, Paddington, NSW.

LARNACH, James McDonald
PSN 21.9.1859. Exhibit: 19.12.1859, Fourteen photographic prints showing different methods of processing. Merchant; a director of Aust. Gas Light Co., Sydney.

LAVERS, J[osiah] V[incent]
PSN 13.6.1856. Cordial and blacking manufacturer, Sydney.

LEATHES, A[lfred] Stranger
PSN 5.10.1864. Insurance secretary. D. 8.6. 1895, Sydney.

LEIBIUS, [Carl] Adolph[us]
PSN 16.11.1859, council 1864-65. RSN 1867-1893. Papers to PSN: 21.11.1860, "On the mundic quartz of Adelong"; 2.11.1864, "On osmium and iridium obtained from New South Wales gold" printed in Trans. PSN: 210-215. Chemist; assayer, Sydney Branch Royal Mint. B. 1833, Wurttemberg, Germany; d. 19.6.1893, Burwood, NSW. See ADB 5:79; J&P 28:36.

LESLIE, Patrick
PSN 13.5.1857. Pastoralist, magistrate and politician. B. 25.9.1815, Aberdeenshire, Scot.; d. 12.8.1881, Milson's Point, NSW. See ADB 2:107-8; Connolly p.195.

LETHBRIDGE, Capt. [Robert] [of 'Flushcombe']
PSN 13.8.1856. Pastoralist in Prospect and Gwydir dists., NSW. B. c1790 England; d. 3.6.1864, Southampton, Eng. See Connolly p. 185 (not Capt. R.N.) Note: not Robert Copland Lethbridge of Penrith dist., or Robert Lethbridge of Falbrook.

LEVINGE, Thomas W[illiam]
PSN 13.6.1856. School teacher and inspector; postal official. D. 1884, Paddington, NSW.

9 Highfield Rd.,
Lindfield, N.S.W., 2070.

(Manuscript received 28.5.1984)

HARLEY WESTON WOOD

Harley Wood who died at his home at Kenthurst on 26th June, 1984, was an outstanding member of the Royal Society of New South Wales. He joined the Society in 1936 and served on the Council for the years 1943-47, 1950, 1953, and 1956-61. He was Honorary Secretary in 1948, 1951 and 1958-61, and President in 1949-50. He contributed fifteen papers to the Journal and Proceedings including the Chapter on "The Sky and the Weather" in the Centenary Volume. He was awarded the Medal of the Royal Society in 1963.

Harley Wood was born at Gulgong on 31 July 1911 and attended Mudgee High School. Here he first became interested in astronomy and constructed a small telescope for himself. He came to Sydney University in 1929 with a State Bursary and a scholarship to Wesley College. He graduated Bachelor of Science in 1933 with first class honours in mathematics and physics and Master of Science in 1934. In 1965 Harley was awarded the degree of Doctor of Science by the University for "Contributions to Astrometry.

After two years as a teacher in the N.S.W. Department of Education, Harley came to Sydney Observatory in 1936 as assistant astronomer. He was appointed Acting Government Astronomer in 1941 and Government Astronomer in 1943. The main scientific work of the Observatory at that time was the Sydney section of the Astrographic Catalogue. This was a plan to photograph the whole sky to a faint magnitude and to measure the positions and brightnesses of the stars, which had been agreed to at an international conference in Paris in 1887. Sydney was allotted a large zone of the southern sky but the work had progressed rather fitfully due to a number of different causes. Thus, by 1941 less than half of the planned volumes of the Sydney section had been published. Harley Wood reactivated the project and as a result of his energy and his inspiration on other members of the staff, the whole of the measurement of the plates was finished by 1955 and the last volume of measures was published in 1964.

In 1944 Melbourne Observatory, which had been working on another section of the Astrographic Catalogue was closed by the Victorian Government. Of its section only three volumes of a planned eight had been published and in 1948 the General Assembly of the International Astronomical Union asked Harley Wood to complete the work at Sydney. A considerable amount of manuscript was in existence but a large amount of checking and reduction and some measuring had still to be done. The printing was mainly done at Paris under the direction of Dr. Jules Baillaud who was chairman of the Commission of the I.A.U. which was responsible for the entire catalogue. The last volume was printed in Sydney in 1964. Dr. Baillaud spoke very highly of Harley's contribution to this great international project.

From 1947 Harley began to plan new programmes of observation for Sydney Observatory and was able to obtain new instruments to carry these out. The Melbourne Astrographic telescope was obtained for Sydney and a new dome constructed to house it. A new wide angle camera was attached to the astrograph and a long screw measuring machine was

Fig. 1. Dr. Harley Wood

obtained. A plan to photograph a large section of the southern sky with the wide angle camer was initiated by Harley in 1958. A second measuring machine to measure these plates was ordered in 1961 and delivered in 1966 but because of delays and difficulties with it the measurement of the plates was not begun until after Harley had retired in 1974. As a result only a portion of the project was completed when in 1982 the New South Wales Government announced that observations were to cease at Sydney Observatory. This was a bitter blow to Harley and greatly saddened the last two years of his life. The catalogue resulting from his work was published in the Journal and Proceedings (Volume 116, p.53, 1983).

Harley Wood had a wide influence in bodies promoting astronomy in Australia and overseas. He was elected to the International Astronomical Union in 1947 and attended its General Assemblies in 1955, 1964, 1967, 1970 and 1973. He was a member of the organizing committees of several of the Commissions of the Union which dealt with positional astronomy. He took part in international conferences on astrometry at Cincinnati in 1959 and Minneapolis in 1970 at the invitation of the United States National Science Foundation. He was a member of the Australian National Committee for Astronomy and was appointed its chairman by the Academy of Science for the period 1966-74. During this time the Committee's main task was the preparation for the General Assembly of the I.A.U. which was held in Sydney in August 1973. Harley was also Chairman of the Local Organizing Committee and by his sustained effort and inspired leadership saw the meeting through to a satisfactory completion. He even compiled the handbook on Australian Astronomy which was issued to delegates. It was generally agreed by members of the I.A.U.

that the Sydney meeting was a most successful and happy one.

Harley took a great interest in the search for a site for a large telescope in Australia which culminated in the erection of the Anglo Australian telescope at Siding Spring Mountain. This was first shown in his Presidential Address to the Royal Society in 1950, entitled Astronomy in Australia, which examined the meteorological and other conditions required for such a site and pointed out the areas in Australia most likely to be suitable. He travelled to many sites in New South Wales partly in company with astronomers from overseas and from the A.N.U. He was also seeking a site for a country station for Sydney Observatory resulting from approval for "preliminary investigations" being given by the Premier of New South Wales. The result of all his investigations was published in 1974 but the project never came to fruition.

Harley was a foundation member of the Astronomical Society of Australia and its first president in 1966-68. He was president of the N.S.W. Branch of the British Astronomical Association in 1940-42 and 1954-55. He gave lectures in spherical astronomy in the Department of Applied Mathematics at Sydney University from 1959 to 1971 and on general astronomy to classes organized by the W.E.A. and the Department of Adult Education of the University. He wrote three books "The Southern Sky", "Unveiling the Universe" and "Planets Suns and Galaxies".

Harley was greatly loved and respected by his staff at Sydney Observatory and by a wide circle of friends both in Australia and overseas. The hospitality extended in their home by Harley and his wife Una is remembered by the great number of colleagues who called at the Observatory when visiting Sydney. He will be greatly missed by us all but we are thankful for having known him and for his long career of service and achievement.

W.H. Robertson

SYDNEY ERNEST BENTIVOGLIO

Mr. Bentivoglio was born in Sydney on 8th May, 1903, when his parents were on their way from Bologna, Italy to South America. They had not intended to remain in Australia. They gave their son the name "Sydney" after the place where he was born. The family decided to remain in Australia, and Sydney's father taught Italian at the N.S.W. Conservatorium of Music.

Sydney Bentivoglio was educated at Fort Street Boys' High School and later at the University of Sydney where he obtained a Bachelor of Agricultural Science in 1926. He was a very keen sportsman and athlete. While growing up in Coogee he was a life-saver, and played first-grade Rugby Union for Randwick. At Fort Street Boys' High School he held the 100-yard athletics record before John Treloar. A keen skier, he became a foundation member of the Kosciusko Alpine Club.

The problems of viticulture early engaged Mr. Bentivoglio's talents. He was invited to overcome a fungal disease in Penfold-Hyland's historic Grange vineyard at Magill, near Adelaide. However, most of his working years were to be devoted to the allied industry, brewing. In mid-1926 he was appointed a bacteriologist by the leading Sydney brewers, Tooth and Company. After the company acquired Resch's "Waverley" Brewery he was attached to it and was promoted to head brewer in the mid-1950s. He remained with Tooth's until his retirement in the early sixties.

Mr. Bentivoglio owned a property near Yass where he experimented with a chemical method for clearing land for agriculture. After retirement he was able to exercise his talents in landscaping and appreciation of botany. He undertook the planning and development of a holiday complex in Fiji, especially its golf course. He created a magnificent garden at his home at Telegraph Road, Pymble.

Mr. Bentivoglio's many interests included classical music, and the love of fine cars, precision instruments and cameras. Before his eyesight deteriorated in later life, he was a voracious reader. He could speak several languages including classical Italian, French and German, and he travelled extensively.

Sydney Bentivoglio joined the Royal Society in 1926, and later became a Life Member. He died at Killara on 30 June, 1983, aged 80, and is survived by one son and two daughters, and seven grandchildren.

J.A.D.

Members of the Society, December 1984

The year of election to membership and the number of papers contributed to the Society's Journal are shown in brackets, thus: (1934: P6), * indicates Life Membership.

HONORARY MEMBERS

BAXTER, Sir John Philip, KBE, CMG, OBE, PhD, Hon DSc, FTS, FAA, FRACI, FIEAust, MIChemE, 1 Kelso St., Enfield, NSW, 2136. (1950)

BURNET, Sir Frank MacFarlane, OM, AK, KBE, PhD *Lond*, Hon.ScD *Camb*, Hon.DSc *W.Aust. NZ. Harv. Lond. Oxf. Syd. N.S.W. N'cle(NSW) & Monash*, MD, BS, Hon.LLD, FRCP *Lond. & Edin.*, FRACP, FAA, FRS, FACP, Hon.FRCS, FRSE, c/- Dept. of Microbiology, University of Melbourne, Parkville, Vic., 3052. (1949)

CAREY, Emeritus Professor Samuel Warren, AO, DSc *Syd.*, Hon.DSc *P.& N.G.*, FNAI, "Ellimatta", 24 Richardson Ave., Dynnyrne, Tasm., 7000. (1938: P2)

CORNFORTH, Sir John Warcup, CBE, FRS, DPhil *Oxf.*, Royal Society Research Professor, University of Sussex, Sussex, BN1 9Q5, England. (1977: P6).

FIRTH, Emeritus Professor Raymond William, DLitt, MA, PhD, 33 Southwood Avenue, London, N6, England.

HILL, Emeritus Professor Dorothy, CBE, PhD *Camb.*, DSc, Hon.LLD *Qld.*, FRS, FAA, FGS, c/- Dept. of Geology, University of Queensland, St. Lucia, Qld., 4067. (1938: P6)

LE FEVRE, Emeritus Professor Raymond James, PhD DSc *Lond.*, FRIC, FRACI, FRS, FAA, 6 Aubrey Rd., Northbridge, NSW, 2063. (1947: P4; Pres. 1961)

McCARTHY, Frederick David, Hon.DSc *ANU*, Dip Anthr, 10 Tycannah Rd., Northbridge, NSW, 2063. (1947: P1; Pres. 1956)

OLIPHANT, Sir Marcus Laurence Elwin, AC, KBE, PhD, FRS, FAA, 37 Colvin St., Hughes, ACT, 2605. (1948)

PRICE, Sir James Robert, KBE, DSc *Adel*, DPhil *Oxf*, FAA, 2 Ocean View Ave., Red Hill South, Vic, 3937. (1976)

ROSENTHAL-SCHNEIDER, Ilse, PhD, 48 Cambridge Ave., Vaucluse, NSW, 2030. (1948)

WHITE, Sir Frederick William George, KBE, CBE, DSc, PhD, FAA, FRS, 57 Investigator St., Red Hill, ACT, 2603. (1973)

ORDINARY

ADAM, Eric, BE, FIE, MIMechE, 40 Cheltenham Road, Cheltenham, NSW, 2119. (1984)

ADAMSON, Colin Lachlan, BSc, 43 Holt Ave., Cremorne, NSW, 2090. (1944)

ADKINS, George Earl, ASTC, AMAustIM, AMIE Aust, Dip App Sc, 157 Doncaster Ave., Kensington, NSW, 2033. (1960)

ADRIAN, Jeannette, BSc, Geological Survey of N.S.W., State Office Block, Phillip St., Sydney, NSW, 2000. (1970)

AITKEN, Janet Mary, BSc, MPhil, 82 Mimosa Rd., Greenacre, NSW, 2190. (1976)

ALBANI, Alberto, DrGeolSc *Florence*, MSc PhD *NSW*, School of Applied Geology, University of N.S.W., Kensington, NSW, 2033. (1973: P4)

*ALBERT, Emeritus Professor Adrien, DSc *Lond*, BSc *Syd*, FAA, FRCS, Flat 15, Block 13, Northbourne Flats, Braddon, ACT, 2601. (1938: P4)

ANDERSON, Christopher William, P.O. Box 30, Chatswood, NSW, 2067. (1975)

ANDERSON, Geoffrey William, BSc, BE, P.O. Box 30, Chatswood, NSW, 2067. (1948)

ARDITTO, Peter Andrew, MSc, BSc, Dip Ed, 20 Burnell St., Drummoyne, NSW, 2047. (1981)

BADHAM, Charles David, MB, BS, DR *Syd*, FRACR, BSc *NSW*, "New Lodge", 16 Ormonde Parade, Hurstville, NSW, 2220. (1962)

BAHADUR, Krishna, MSc, DPhil, DSc, DIC *Lond.*, Chemistry Dept., University of Allahabad, 68 Dilkusha, New Katra, Allahabad, 211002, India. (1980: P2)

*BAKER, Stanley Charles, PhD, MSc, FAIP, Professor of Physics, 4 Aldyth St., New Lambton, NSW, 2305. (1934: P4)

BANFIELD, James Edmund, MSc, PhD *Melb*, Dept. of Organic Chemistry, University of New England, Armidale, NSW, 2351. (1963)

BANKS, Maxwell Robert, AM, BSc *Syd.*, DSc, Dr (HC) *France, Lille*, Dept. of Geology, University of Tasmania, Hobart, Tasm., 7000. (1951)

BARKAS, John Pallister, BSc, P.O. Box 38, Spit Junction, NSW, 2088. (1972)

BARRY, Jerard Michael, BSc, PhD *Wollongong*, 7 Geelong Rd., Engadine, NSW, 2233. (1974)

BASDEN, Helena, BSc, Dip Ed, 3 Norfolk Ave., Collaroy Beach, NSW, 2097. (1970)

BASDEN, Kenneth Spencer, BSc PhD *NSW*, ASTC, CEng, FInstF, FAIE, MIEAust, ARACI, AMAusIMM, Dept. of Fuel Technology, University of N.S.W., Kensington, NSW, 2033. (1951: P1)

BEADLE, Emeritus Professor Noel Charles William, DSc *Syd*, P.O. Box 259, Armidale, NSW, 2350. (1964)

BEALE, James Edgar Osborne, 51 Kembla St., Wollongong, NSW, 2500. (1968)

BEAN, Judith, PhD, c/- P.O. Box 115, Rose Bay, NSW, 2029. (1975: P1)

BEATON, Peter, BSc, BA, ALAA, 108 Newton St., Armidale, NSW, 2350. (1984)

BEATTIE, David Raymond Hamilton, BSc *Syd*, BE Elect, MEngSc *NSW*, 858 Henry Lawson Drive, Picnic Point, NSW, 2213. (1977)

BEAVIS, Francis Clifford, MA *Camb*, BSc PhD *Melb*, FGS, Professor of Engineering Geology, School of Applied Geology, University of N.S.W. Kensington, NSW, 2033. (1973: P1; Pres. 1978)

BENNETT, John Makepeace, BE(Civ) BE(Mech&Elect) BSc *Qld*, PhD *Camb*, FACS, FBCS, FIEAust, FIMA, Professor of Computer Science, University of Sydney, NSW, 2006. (1978)

BHATHAL, Ragbir S., BSc, PhD, Assistant Director, Power House Museum, P.O. Box K346, Haymarket, NSW, 2000. (1982: Pres. 1984)

BILLS, Ross Maynard, Flat 7, 9 Church St., Ashfield, NSW, 2131. (1982)

BINNS, Raymond Albert, BSc *Syd*, PhD *Camb*, CSIRO, Division of Mineral Physics, P.O. Box 136, North Ryde, NSW, 2113. (1964)

BIRCH, Arthur John, Emeritus Professor, MSc *Syd*, *Manc*, DPhil *Oxf*, CMG, FRIC, FRACI, FAA, FRS, Research School of Chemistry, Australian National University, Canberra, ACT, 2600. (1973: P2)

*BISHOP, Eldred George, P.O. Box 13, Mosman, NSW, 2088. (1920)

BLACK, David St Clair, MSc *Syd*, PhD *Camb*, AMusA, FRACI, Professor of Organic Chemistry and Head of Department of Organic Chemistry, University of N.S.W., Kensington, NSW, 2033. (1983)

BLACK, Peter Laurence, 193 Iodide St., Broken Hill, NSW, 2880. (1975)

BLANKS, Fred Roy, BSc, 19 Innes Rd., Greenwich, NSW, 2065. (1948)

BLAXLAND, David George, MB BS *Syd*, 2 Curagul Rd., North Turramurra, NSW, 2074. (1977)

BLAYDEN, Ian Douglas, BSc, 73 Abingdon Rd., Roseville, NSW, 2069. (1966)

BRAIN, Robert, ME, MPhil, MIEAust, 128 Crescent Rd., Newport, NSW, 2106. (1973)

BRAKEL, Albert Theodorus, BSc, PhD, c/- Bureau of Mineral Resources, Geology & Geophysics, P.O. Box 378, Canberra, ACT, 2601. (1968: P1)

BRANAGAN, David Francis, MSc PhD *Syd*, FGS, Dept. of Geology and Geophysics, University of Sydney, NSW, 2006. (1967: P3)

*BRIGGS, George Henry, DSc, 120 Donington Court, Flinders Village, Castle Hill, NSW, 2154. (1919)

BROPHY, Joseph John, BSc PhD *NSW*, DipEd *Monash*, ARACI, Dept. of Organic Chemistry, University of N.S.W., Kensington, NSW, 2033. (1983: P1)

*BROWN, Desmond Joseph, MSc *Syd*, DIC PhD DSc *Lond*, FRACI, 2 Hobbs St., O'Connor, ACT, 2601. (1942)

BROWN, John Huon, BSc, Dept. of Surgery, Westmead Centre, Westmead, NSW, 2145. (1983)

BROWN, Henry Emanuel, MSc, 9 Watford Close, Epping, NSW, 2121. (1975)

BROWN, Kenneth John, ASTC, ARACI, 3 Karda Place, Gymea, NSW, 2227. (1963)

BRYAN, John Hamilton, BSc, PhD, Managing Director, McElroy Bryan and Associates Pty. Ltd., P.O. Box 34, Willoughby, NSW, 2068. (1968)

BUCKLEY, Lindsay Arthur, BSc, 131 Laurel Street, Chelmer, Qld., 4075. (1974)

BURKE, John James, MB BS *Syd*, FRACP, 21 Berrillee Rd., Turramurra, NSW, 2074. (1979)

BURNS, Bruce Bertram, OBE, MDS, Suite 503, 60 Park St., Sydney, NSW, 2000. (1961)

BYRNES, Ann, BSc MSc, 55 Woodside Ave., Strathfield, NSW, 2135. (1978)

CALLAGHAN, Patricia Mary, BSc *Syd*, MSc *Macq*, ALAA, 814/22 Doris St., North Sydney, NSW, 2060. (1984)

CALLENDER, John Hardy, 11 Lisa Valley Close, Wahroonga, NSW, 2076. (1969)

CAMPBELL, Ian Gavin Stuart, BSc, 4/62 Alexandra St., Hunters Hill, NSW, 2110. (1955)

CAMPBELL, Kenton Stewart Wall, MSc PhD *Qld*, FAA, Professor and Head of the Dept. of Geology, Australian National University, Canberra, ACT, 2600. (1975: P1)

CARRINGTON, Richard Hewitt Christopher, ThA, 3 Highlands Ave., Gordon, NSW, 2072. (1983)

CARTER, Alan Norval, BSc PhD *Melb*, MSc *Adel*, 8 Scott St., Maroubra Bay, NSW, 2035. (1982)

CAVILL, Emeritus Professor George William Kenneth, MSc *Syd*, PhD DSc *Liv*, FAA, FRACI, 7/37 The Esplanade, Cronulla, NSW, 2230. (1944: P1)

CHAFFER, Edric Keith, 66 Victoria Ave., Chatswood, NSW, 2067. (1954: P1; Pres. 1975)

*CHALMERS, Robert Oliver, c/- The Australian Museum, College St., Sydney, NSW, 2000. (1933: P1)

CHANDLER, Garry Anthony, VRD, MRIPA, JP, 5/18 Church St., Magill, SA, 5072. (1975)

CHIVAS, Allan Ross, BSc PhD *Syd*, Research School of Earth Sciences, Australian National University, Canberra, ACT, 2600. (1972)

CHOWDHURY, Nazmul Karim, BSc, 34 Keeler St., Carlingford, NSW, 2118. (1974)

*CHURCHWARD, John Gordon, BSc Agr, PhD, 12 Glen Shian Lane, Mount Eliza, Vic., 3930. (1935: P2)

CLANCY, Brian Edward, MSc, PhD, Australian Atomic Commission, Lucas Heights, NSW, 2232. (1957: P1)

COALSTAD, Stanton Ernest, BSc, 16 Station St., Marrickville, NSW, 2204. (1961)

*COHEN, Samuel Bernard, MSc, 46 Wolseley Rd., Point Piper, NSW, 2027. (1940)

COLE, Edward Ritchie, MSc *Syd*, PhD *NSW*, FRACI, 7 Wolsten Ave., Turramurra, NSW, 2074. (1940: P2)

COLE, Joyce Marie, BSc, 7 Wolsten Ave., Turramurra, NSW, 2074. (1940: P1)

COLE, Trevor William, BE *WA*, PhD *Camb*, Peter Nicol Russell Professor of Electrical Engineering, University of Sydney, NSW, 2006. (1978: P1; Pres. 1982)

COLLETT, Gordon, BSc, 16 Day Rd., Cheltenham, NSW, 2119. (1940)

COLLIER, Margaret A., 135 Highfield Rd., Lindfield, NSW, 2070. (1973)

COOK, Alan Cecil, MA PhD *Camb*, FGS, AMAusIMM, Professor of Geology, University of Wollongong, NSW, 2500. (1968: P2)

COOK, James Lindsay, BSc MSc PhD *NSW*, FAIP, Australian Atomic Energy Commission, Lucas Heights, NSW, 2232. (1982: P1)

*CORTIS-JONES, Beverley, MSc, 19 Medway Drive, Mt. Keira, NSW, 2500. (1940)

COX, Charles Dixon, BSc DipEd *Qld*, 51 Darley St., Forestville, NSW, 2087. (1964)

CREELMAN, Robert Auchterlonie, BA MSc, 108 Midson Rd., Epping, NSW, 2121. (1973)

*CRESSWICK, John Arthur (1921: P1)

CROOK, Keith Alan Waterhouse, MSc *Syd*, PhD *NE*, BA *ANU*, Dept. of Geology, Australian National University, Canberra, ACT, 2600. (1954: P9)

DAVIES, George Frederick, AMIET *Lond*, 57 Eastern Ave., Kingsford, NSW, 2032. (1952)

DAY, Alan Arthur, BSc *Syd*, PhD *Camb*, FRAS, Dept. of Geology and Geophysics, University of Sydney, NSW, 2006. (1952: P3; Pres.1965)

DE LAUNAY, Paul Beaumont, 50 Moonbie St., Summer Hill, NSW, 2130. (1979)

DERRICK, Peter John, BSc PhD *Lond*, ARACI, Professor of Physical Chemistry and Head of Dept. of Physical Chemistry, University of N.S.W., Kensington, NSW, 2033. (1983)

DOLANSKI, Joseph, BSc, Min Geo Consultant & Research Services, P.O. Box 77, Tumbi Umbi, NSW, 2261. (1975)

*DONEGAN, Henry Arthur James, AM, MSc, ASTC, FRSC, FRACI, MAustIMM, Senior MACS, 18 Hillview St. Sans Souci, NSW, 2219. (1928: P1; Pres.1960)

DOWNES, Peter Michael, MASc, 9/28 Greenoak Ave., Como, WA, 6152. (1975)

DRAKE, Lawrence Arthur, BA BSc *Melb*, MA PhD *Calif*, Director, Riverview College Observatory, Riverview, NSW, 2066. (1962: P3)

DRUMMOND, David Gordon, MSc, PhD, FInstP, 45 Albert Drive, West Killara, NSW, 2071. (1975)

*DULHUNTY, John Allan, DSc *Syd*, Dept. of Geology and Geophysics, Sydney University, NSW, 2006. (1937: P27; Pres. 1947)

EAGLE, Ann Hansi, 1202/349 New South Head Rd., Double Bay, NSW, 2028. (1979)

EDWARDS, Robert John, BSc, Grad Dip Appl Geophysics, 205 Davey St., Hobart, Tas., 7000. (1974)

ELLISON, Dorothy Jean, MSc, 45 Victoria St., Roseville, NSW, 2069. (1949)

EMERY, Hilary May Myvanwy, 53 Byron St., Bulimba, Qld., 4171. (1965)

EMMERTON, Henry James, BSc, 37 Wangoola St., Gordon, NSW, 2072. (1940)

ENGEL, Brian Adolph, MSc *NE*, PhD, Dept. of Geology, University of Newcastle, Newcastle, NSW, 2308. (1961: P1)

EVANS, Philip Richard, BA *Oxf*, PhD *Brist*, FGS, School of Applied Geology, University of N.S.W. Kensington, NSW, 2033. (1968: P2)

FACER, Richard Andrew, BSc PhD *Syd*, AMAusIMM, MGSAm, MAGU, Esso Australia Ltd., G.P.O. Box 4047, Sydney, NSW, 2001. (1965: P3)

FAYLE, Rex Dennes Harris, Dip Pharm, P.O. Box 261, Armidale, NSW, 2350. (1961)

FELTON, Elizabeth Anne, BSc *ANU*, FGAA, 8 Nardoo Cres., O'Connor, ACT, 2601. (1977)

FERGUSSON, Christopher Lloyd, BA *Macq*, PhD *NE*, Dept. of Earth Sciences, Monash University, Clayton, Vic. 3168. (1980: P3)

FERGUSSON, Jocelyn, BSc, DipEd, c/- Dept. of Geology, University of New England, Armidale, NSW, 2351. (1980)

FINLAY, Cecily June, BSc *Syd*, CSIRO, Minerals Research Laboratories, P.O. Box 136, North Ryde, NSW, 2113. (1975)

FLEISCHMANN, Arnold Walter, 5 Erang St., Carss Park, NSW, 2221. (1956)

*FLETCHER, Harold Oswald , MSc, 12A Western Rd., Castle Hill, NSW, 2154. (1933)

FLOOD, Peter Gerard, BSc, MSc, PhD *NE*, Dept. of Geology, University of New England, Armidale, NSW, 2351. (1982)

FOLDVARY, Gabor Zoltan, BSc, MSc *NSW*, 267 Beauchamp Rd., Matraville, NSW, 2036. (1965: P1)

FORD, George William Kinvig, MA *Camb*, 133 Wattle Rd., Jannali, NSW, 2226. (1974)

FRAZER, Geoffrey Leon, 4 Bradley Drive, Carlingford, NSW, 2118. (1976)

FREEDMAN, Albert, MB BS *Syd*, FRCP, FRACP, DCH, 57 Darlinghurst Rd., Kings Cross, NSW, 2011. (1984)

FRENCH, Oswald Raymond, 6 Herberton Ave., Hunters Hill, NSW, 2110. (1951)

FROST, Dennis John, Esso Exploration, G.P.O. Box 4047, Sydney, NSW, 2001. (1983)

FROST, Janet Patricia, BA, DipEd, 9 Panorama St., Kooringal, NSW, 2650. (1977)

GAGE, William Henry, P.O. Box 130, Avalon, NSW, 2170. (1982)

*GARRETTY, Michael Duhan, DSc, P.O. Box 217, Toorak, Vic. 3142. (1935: P2)

*GASCOIGNE, Robert Mortimer, PhD, 5 Wahroonga Ave., Wahroonga, NSW, 2076. (1939: P4)

GIBBONS, George Studley, MSc *Syd*, PhD *NSW*, 8 Marsh Place, Lane Cove, NSW, 2066. (1966: P2; Pres. 1980)

GIBSON, Neville Allan, MSc PhD *Syd*, MRSC, ARIC, 103 Bland St., Ashfield, NSW, 2131. (1942: P6)

GILLESPIE, Peter James, BSc BE *Syd*, 8 Alexander St. Mosman, NSW, 2088. (1977)

GLASSON, Kenneth Roderick, BSc PhD *Syd*, 76 Charles Ave., Minamurra, NSW, 2532. (1948: P1)

GLEN, Richard Arthur, BSc, PhD *Adel*, Geological Survey of N.S.W., G.P.O. Box 5288, Sydney, NSW, 2001. (1983: P2)

*GOLDING, Henry George, MSc, PhD, 361 Burns Bay Rd., Lane Cove, NSW, 2066. (1953: P6)

GOULD, Rodney Edward, BSc, PhD *Qld*, 17 Jarup St., Jindalee, Qld, 4074. (1973: P3)

GOVETT, Gerald James Spurgeon, CEng, DSc *Wales*, PhD DIC *Lond*, FIMM, Professor of Geology & Head of School, School of Applied Geology, University of NSW, Kensington, NSW, 2033. (1979)

GOW, Neil Neville, BSc, c/- A.M. and S. Canada Minerals Ltd., P.O. Box 238 Toronto-Dominion Centre, Toronto, Ont, M4K 1J3, Canada. (1966)

GRANT, John Guerrato, DipEng, 37 Chalayer St., Rose Bay, NSW, 2029. (1961)

GRAY, Noel Mackintosh, BSc, 1 Centenary Ave., Hunters Hill, NSW, 2110. (1952)

*GRIFFITH, James Langford, BA, MSc, 9 Kanoona St., Caringbah, NSW, 2229. (1952: P17; Pres.1958)

GUTMANN, Felix, PhD *Vienna*, FInstP, FAIPS, FAIP, 70A Victoria Rd., West Pennant Hills, NSW, 2120. (1946: P1)

GUY, Brian Bertram, BSc PhD *Syd*, 8 Tivoli Ave., Rose Bay, NSW, 2029. (1968: P2)

HACKETT, Ian Harry, BSc, 11 High St., Epping, NSW, 2121. (1968)

*HALL, Norman Frederick Blake, MSc, 67 Wookarra Ave., Elanora Heights, NSW, 2101. (1934)

HANCOCK, Harry Sheffield, MSc *Syd*, 16 Koora Ave., Wahroonga, NSW, 2076. (1955)

*HANLON, Frederick Noel, BSc, 21/43 Musgrave St., Mosman, NSW, 2088. (1940: P14; Pres.1957)

HARDIE, John Robert, BSc, FGS, 26/351 Edgecliff Rd., Edgecliff, NSW, 2027. (1979)

HARDWICK, Reginald Leslie, MEd, BSc, Grad Dip Hydrogeology, Director of Audio Visual Services, University of Queensland, St. Lucia, Qld, 4067. (1968)

HARDY, Clarence James, BSc, PhD, DSc, C Chem, FRIC, MAustIMM, 12 Brassie St., North Bondi, NSW, 2026. (1976)

HARPER, Arthur Frederick Alan, AO, MSc, Hon FAIP, FInstP, 23 Bareena Drive, Balgowlah, NSW, 2093. (1936: P1; Pres.1959)

HAWKINS, David, 50 Beaumont Rd., Killara, NSW, 2071. (1975)

HAYDON, Sydney Charles, MA *Oxf*, PhD *Wales*, FInst P, FAIP, Professor of Physics, University of New England, Armidale, NSW, 2351. (1965)

*HAYES, Daphne, BSc, 108 Elizabeth Bay Rd., Elizabeth Bay, NSW, 2011. (1943)

HELBY, Robin James, MSc, PhD, 356 Burns Bay Rd., Lane Cove, NSW, 2066. (1966: P3)

HODGINS, Reginald William, ASTC, BSc, 71 Kembla St., Wollongong, NSW, 2500. (1967)

HODGSON, Jack Dudley, MIE, P.O. Box 389, Mona Vale, NSW, 2103. (1982)

HUMPHRIES, John William, BSc, MInstP, 27 Eustace Parade, Killara, NSW, 2071. (1959: P1; Pres. 1964)

JENKINS, Thomas Benjamin Huw, BSc PhD *Wales*, FGS, Dept. of Geology and Geophysics, University of Sydney, NSW, 2006. (1956)

JEZ, Joseph, ARAIA, 57 Young St., Sylvania Heights, NSW, 2224. (1974)

JOHNSON, Brian David, BA (Hons), PhD, 17 Douglass Ave., Carlingford, NSW, 2118. (1975)

*JOPLIN, Germaine Anne, PhD, DSc, 5/200 Pacific Highway, Lindfield, NSW, 2070. (1935: P10)

JONES, The Honourable Barry O., M.P., Minister for Science and Technology, Parliament House, Canberra, ACT, 2600. (1984: P1)

JONES, John Clifford, BSc, PhD *Leeds*, Flat 2, 21 Bruce St., Toorak, Vic., 3142. (1981)

KALOKERINOS, Archivides, MB BS, FACMT, 35 Chaleyer St., Rose Bay, NSW, 2029. (1970)

KASTALSKY, Victor, BSc PhD *NSW*, ASTC, MInstP, MAIP, 51 Kilbride St., Hurlstone Park, NSW, 2193. (1979)

KELLY, John Charles, BS *Syd*, PhD *Reading*, DSc *NSW*, FInst P, MAIP, MAmPS, 69 Yeramba St., Turramurra, NSW, 2074. (1975)

KEMENY, Leslie George, BE *Syd*, MIE Aust, 21 Westmeath Ave., Killarney Heights, NSW, 2087. (1975)

KIDD, Susan Elizabeth, BA DipEd, 16 Bowen Ave., Turramurra, NSW, 2074. (1984)

KING, David Stephen, BSc Hons, 142 Cressy Rd., North Ryde, NSW, 2113. (1977: P12)

KING, Haddon Forrester, BAppSc (Min Eng), P.O. Box 47, Kallista, Vic., 3791. (1973)

KING, Harold Marflet, 20 Beaumont Rd., Killara, NSW, 2071. (1974)

KOCH, Leo E., DPhil *Habil*, 21 Treatts Rd., Lindfield, NSW, 2070. (1948)

KORSCH, Russell John, BSc DipEd PhD *NE*, Dept. of Geology, Victoria University of Wellington, Private Bag, Wellington, New Zealand. (1971: P10)

KRYSKO von TRYST, Maren, BSc, GradDip *NSW*, AMAusIMM, 116 Midson Rd., Epping, NSW, 2121. (1959)

LABUTIS, Vidmantas Romualdas, BSc *ANU*, MSc *Macq*, c/- Esso Aust. Exploration, 127 Kent St., Sydney, NSW, 2000. (1973)

LANDER, John, MB, BS, BSc Med, PhD, 19 Dalton Rd., St. Ives, NSW, 2075. (1977)

LASSAK, Erich Vincent, PhD, MSc, BSc Hons, ASTC, Reader in Chemistry, School of Natural Resources, University of South Pacific, P.O.B. 1168, Suva, Fiji. (1964: P3)

LATHAM, John Victor, MB BS, FRACP, 39 Woniora Rd., Hurstville, NSW, 2220. (1981)

LAU CHI-KIN, Vincent, (1983)

LAU, Henry Po Kun, MB BS, FRCPA, Suite 4, Ash-don House, 57 Mitchell St., North Ward, Townsville, Qld, 4810. (1979)

LAWRANCE, Anthony Bohun, BSc *WA*, MBA *NSW*, 4 Yarrawonga Close, Pymble, NSW, 2073. (1980)

LAWRENCE, Laurence James, DSc DipCom *Syd*, PhD *NSW*, DIC, MAusIMM, 15 Japonica Rd., Epping, NSW, 2121. (1951)

LEAVER, Gaynor Eluned, BSc *Wales*, FGS *Lond*, 30 Ingalara Ave., Wahroonga, NSW, 2076. (1961)

LEITCH, Evan Charles, MSc *Auck*, PhD *NE*, FGS, Dept. of Geology and Geophysics, University of Sydney, NSW, 2006. (1980)

LEVY, Bernard Henry John, LLB, 66 Victoria Rd., Bellevue Hill, NSW, 2023. (1979)

LINDLEY, Ian David, BSc PhD *NSW*, Esso Papua New Guinea, P.O. Box 536, Rabaul, Papua New Guinea. (1980: P2)

LIONS, Jean Elizabeth, BSc, 93A Mona Vale Rd., Pymble, NSW, 2073. (1940)

LOCKWOOD, William Hutton, BSc, 129 High St., North Sydney, NSW, 2060. (1940: P1)

LOMB, Nicholas Ralph, BSc, PhD, Sydney Observatory, Observatory Hill, Sydney, NSW, 2000. (1980: P5)

LOUGHNAN, Frederick Charles, BSc *Syd*, PhD DSc *NSW*, AMAusIMM, School of Applied Geology, University of N.S.W., Kensington, NSW, 2033. (1979: P1)

LOW, Angus Henry, MSc DipEd *Syd*, PhD *NSW*, School of Mathematics, University of N.S.W., Kensington, NSW, 2033. (1950: P4; Pres. 1967)

LOWE, Stephen Paul, BSc, 12 Blackbutt Ave., Bradbury, NSW, 2560. (1974)

LOXTON, John Harold, MSc *Melb*, PhD *Camb*, School of Mathematics, University of N.S.W., Kensington, NSW, 2033. (1974)

LUCAS, James Patrick, 80 Shellcove Rd., Neutral Bay, NSW, 2089. (1971)

LYONS, Lawrence Ernest, BA MSc *Syd*, PhD DSc *Lond*, FRACI, FAA, Professor of Physical Chemistry, University of Queensland, St. Lucia, Qld, 4067. (1948: P3)

LYONS, Michael Thomas, Dip Tech (Sc) *NSWIT*, MChem *NSW*, 24 Woorak Cres., Miranda, NSW, 2228. (1974: P1)

McAULEY, William John Watson, P.O. Box 16, Church St., Brighton, Vic, 3186. (1975)

McELROY, Clifford Turner, MSc PhD *Syd*, MAppSc *NSW*, P.O. Box 34, Willoughby, NSW, 2068. (1949: P2)

McGHEE, Moira Elizabeth, 28 Nielson Ave., Carlton, NSW, 2218. (1975)

MacKELLAR, Michael John Randal, BSc Agr *Syd*, BA Hons *Oxf*, 1 Lewis St., Balgowlah Heights, NSW, 2093. (1968)

*McKERN, Howard Hamlet Gordon, MSc, ASTC, FRACI, 10 Beaconsfield Pde., Lindfield, NSW, 2070. (1943: P12; Pres.1963)

McLEAN, Ross Alastair, BSc, PhD, c/- Amoco Canada Petroleum Co. Ltd., Amoco Canada Building, 444 Seventh Ave. S.W., Calgary, Alberta, T2P 0Y2, Canada. (1973: P2)

MacLEOD, Roy Malcolm, AB *Harv*, PhD *Camb*, FRHistS, Professor of History, University of Sydney, NSW, 2006. (1983)

McMINN, Andrew, BSc, Geological Survey of N.S.W., 36 George St., Sydney, NSW, 2000. (1981: P1)

McNAMARA, Barbara Joyce, MB BS, Flat 7, 58 Ocean St., Woollahra, NSW, 2025. (1943)

McNAUGHTON, John Edwin, Palmer, Bruyn and Walpole (Surveyors), 19 Bolton St., Newcastle, NSW, 2300. (1982)

MAGEE, Charles Joseph, DSc Agr, 57 Florida Rd., Palm Beach, NSW, 2108. (1947: P2; Pres.1952)

MAJSTRENKO, Petro, MSc *Copenhagen*, Flat 8, 41-47 Bellevue St., Glebe, NSW, 2037. (1966)

MALCOLM, Harvey Donald Robert, MSc *Syd*, PhD *Macq*, P.O. Box 77, Laurieton, NSW, 2443. (1974: P1)

MARTIN, Helene Alice, MSc *Adel*, PhD *NSW*, School of Botany, University of N.S.W., Kensington, NSW, 2033. (1976: P7)

MARTIN, Peter Marcus, MSc Agr, PhD, DipEd, Executive Member, N.S.W. Higher Education Board, A.D.C. Building, 189 Kent St., Sydney, NSW, 2000. (1968)

MATTOCKS, Julie Margaret, 13 Balyata Ave., Caringbah, NSW, 2229. (1980)

MATTOCKS, Kylie Maitland, MB BS, DCP, FRCPA, FRCPath, FAACB, 13 Balyata Ave., Caringbah, NSW, 2229. (1978)

MAWSON, Ruth, BA, School of Earth Sciences, Macquarie University, North Ryde, NSW, 2113. (1974: P1)

MIKULSKI, John, BSc, 56 Kyooma St., Tamworth, NSW, 2340. (1976)

MILLER, Desmond, MB, BCh, FFPath *S Afr*, FRCPA, 29 Clyde St., North Bondi, NSW, 2026. (1981)

*MILLERSHIP, William Wreford, BSc MSc *Syd*, 18 Courallie Ave., Pymble, NSW, 2073. (1940)

MITCHELL, Robert Mervyn, BMedSc *Otago*, MB ChM *NZ*, FRCS, FRACS, Professor of Surgery, St. George Hospital, Kogarah, NSW, 2217. (1979)

MOLLOY, Peter David, BA, MSc, 30 Carlotta Gordon, NSW, 2072. (1975)

MONAGHAN, Gregory, MB BS, 4 Maple St., Lugarno, NSW, 2210. (1984)

MORGAN, Noel Charles, 21 Page St., Canterbury, NSW, 2193. (1973)

*MORT, Francis George Arnot, 29 Preston Ave., 2046. (1934)

MORY, Arthur John, BSc, c/- Geological Survey of Western Australia, 66 Adelaide Terrace, Perth, WA, 6000. (1980: P1)

MOSHER, Kenneth George, AM, OBE, ED, BSc, 9 Yirgella Ave., Killara, NSW, 2071. (1948)

MOSKOS, Michael, BE *NSW*, 21 Baringa Rd., Northbridge, NSW, 2063. (1975)

MURRAY, Bede Edward, BA, 15 Spring St., Mount Keira, NSW, 2500. (1969)

NAPPER, Donald Harold, MSc *Syd*, PhD *Camb*, FRACI, Dept. of Physical Chemistry, University of Sydney, NSW, 2006. (1973: P1; Pres.1979)

NASHER, Beryl, PhD, Emeritus Professor of Geology, 43 Princeton Ave., Adamstown Heights, NSW, 2289. (1946: P3)

NAZER, Roderick Eric, PhD, Canberra Grammar School, Monaro Crescent, Red Hill, ACT, 2603. (1975: P1)

*NEUHAUS, John William George, MSc, 3 Turner Ave., Baulkham Hills, NSW, 2153. (1943: P1; Pres. 1969)

*NEWMAN, Ivor Vickery, PhD, 1 Stuart St., Wahroonga, NSW, 2076. (1932)

NOAKES, Lyndon Charles, OBE, BA, 15 Beagle St., Red Hill, ACT, 2603. (1945: P1)

O'KEEFFE, Edward Donald, BSc DipEd *Syd*, MSc *Macq*, 22/116 Herring Rd., Eastwood, NSW, 2122. (1984)

O'SHEA, Timothy, MSc, BVSc, PhD, Dept. of Physiology, University of New England, Armidale, NSW, 2351. (1973)

OSBORNE, Robert Armstrong Lee, MSc, DipEd, Dept. of Geology and Geophysics, University of Sydney, NSW, 2006. (1984: P1)

OXENFORD, Reginald Augustus, BSc, 1 Balmoral Rd., Ringwood North, Vic, 3134. (1950)

PACKHAM, Gordon Howard, BSc PhD *Syd*, Dept. of Geology and Geophysics, University of Sydney, NSW, 2006. (1951: P4)

PARTRIDGE, Alan Douglas, BSc *Syd*, MSc *NSW*, c/- Esso Australia Ltd., G.P.O. Box 4047, Sydney, NSW, 2001. (1977)

PAWLOFF, Theodora, MD, DOM, MRANZCP, 680 Victoria Rd., Ryde, NSW, 2112. (1979)

PEARCE, Marcelle Gordon Ivy, MSc *Melb*, C.S.I.R.O. Division of Applied Physics, p.r. 108 Burns Rd., Wahroonga, NSW, 2076. (1967)

PERRY, Hubert Roy, BSc, P.O. Box 547, Bowral, NSW, 2576. (1948)

PHILIP, Graeme Maxwell, PhD *Camb*, MSc *Melb*, FGS, MAIMM, Edgeworth David Professor of Geology, Dept. of Geology and Geophysics, University of Sydney, NSW, 2006. (1964: P2)

PHILIPP, Donald Henry, BSc, ASTC, 90 Spencer Rd., Killara, NSW, 2071. (1979)

PHIPPS, Charles Verling Gayer, PhD *Toronto*, BSc *Syd*, Dept. of Geology and Geophysics, University of Sydney, NSW, 2006. (1960)

PICKETT, John William, MSc *NE*, Dr Phil Nat *Frankfurt/M*, Geological Survey of N.S.W., Mining Museum, 36 George St., Sydney, NSW, 2000. (1965: P3; Pres.1974)

PISANI, Victor Robert, BAppSc, Centre for Environmental and Urban Studies, Macquarie University, North Ryde, NSW, 2113. (1980)

PLIMER, Ian Rutherford, BSc, PhD, Professor of Geology, University of Newcastle, NSW, 2308. (1982)

POGSON, Ross Edward, DipTechSc *NSWIT*, BAppSc, 178 Marco Ave., Panania, NSW, 2213. (1979)

POLLARD, John Percival, MSc PhD *NSW*, DipAppChem *Swinburne*, 89 Bunarba Rd., Gymea, NSW, 2227. (1963: P1; Pres.1973)

POWER, Paul Anthony, BSc *Syd*, MSc *NSW*, DipLaw BAB, ARACI, MRSC, CChem, AIArbA, 178 Newland St., Bondi Junction, NSW, 2022. (1980)

PROKHOVNIK, Simon Jacques, BA MSc *Melb*, c/- Dept. of Theoretical and Applied Mechanics, School of Mathematics, University of N.S.W., Kensington, NSW, 2033. (1956: P4)

*PROUD, Sir John Seymour, Kt, BE, Finlay Rd., Turramurra, NSW, 2074. (1945)

PROWSE, David Benjamin, BSc, MSc, PhD, 2 Spencer Rd., Killara, NSW, 2071. (1978)

PUTTOCK, Alan Maurice, FCA, Messrs. Wylie and Puttock, 39-41 York St., Sydney, NSW, 2000. (1969)

PUTTOCK, Maurice James, BSc Eng, MInstP, 2 Montreal Ave., Killara, NSW, 2071. (1960: P1; Pres.1971)

*QUODLING, Florrie Mabel, BSc PhD *Syd*, The Cotswolds Apartment 22, Curagul Road, North Turramurra, NSW, 2074. (1935: P5)

RADE, Janis, MSc, The Rade Stratigraphic Laboratory, G.P.O. Box 5440C, Melbourne, Vic, 3001. (1953: P6)

RAMM, Eric John, Australian Atomic Energy Commission, Lucas Heights, NSW, 2232. (1959)

RANCE, Bruce E., 16 Orana Rd., Kenthurst, NSW, 2154. (1981)

RATTIGAN, John Herbert, PhD, 21 Kildare Grove, Killarney Heights, NSW, 2087. (1966: P2)

READ, Richard Hoskin, BScAgr *Syd*, MSc *Reading*, Dip Air Photo Interpretation, DipInst de Francaise *France*, Dept. of Agriculture, Minister's Advisory Unit, 11th Floor, McKell Building, Rawson Place, Sydney, NSW, 2000. (1983)

REDDECLIFFE, Owen Andrew, BSc, 8 Warrowa Ave., West Pymble, NSW, 2073. (1984)

RICE, Thomas Denis, BSc MSc *Syd*, 5 Harden Rd., Artarmon, NSW, 2064. (1964)

RICKARD, Kevin, MB BS, FRACP, FRCPA, MRCPath, FCAP, 117 Blackbutts Rd., French's Forest, NSW, 2086. (1977)

RICKWOOD, Peter Cyril, BSc *Lond*, PhD *Cape Town*, CChem, FGS, MRIC, School of Applied Geology, University of N.S.W., Kensington, NSW, 2033. (1974)

RIGBY, John Francis, PhD, Geological Survey of Queensland, G.P.O. Box 194, Brisbane, Qld, 4001. (1963)

RIGGS, Noel Victor, BSc *Adel*, PhD *Camb*, FRACI, Professor of Organic Chemistry, University of New England, Armidale, NSW, 2351. (1961)

RILEY, Steven James, BSc PhD *Syd*, MEngSci, School of Earth Sciences, Macquarie University, North Ryde, NSW, 2113. (1969)

RITCHIE, Arthur Sinclair, MSc, 18 Madison Drive, Adamstown, NSW, 2289. (1947: P2)

ROBBINS, Elizabeth Marie, MSc, 34 Bedford Rd., Woodford, NSW, 2778. (1939: P3)

ROBERTS, Herbert Gordon, BSc, c/- P.O. Box 529, Manuka, ACT, 2603. (1957)

ROBERTS, John, BSc *NE*, PhD *WA*, School of Applied Geology, University of N.S.W., Kensington, NSW, 2033. (1961: P5)

ROBERTSON, William Humphrey, BSc, 1 Dunmore St., Epping, NSW, 2121. (1949: P35; Pres.1977)

ROBERTSON-CUNINGHAME, Robert Clarence, BScAgr *Syd*, DPhil *Oxf*, Chancellor of the University of New England, "Gartmore", Deepwater, NSW, 2371. (1982)

ROBINSON, David Hugh, ASTC, 12 Robert Rd., West Pennant Hills, NSW, 2120. (1951)

ROGERSON, BSc PhD *Syd*, PNG Geological Survey, P.O. Box 778, Port Moresby, Papua New Guinea. (1979)

*ROUNTREE, Phyllis Margaret, DSc *Melb*, DipBact *Lond*, 7 Windsor St., Paddington, NSW, 2021. (1945)

ROY, Peter Stanton, BSc, PhD, DIC, 16 Hodgson Ave., Cremorne, NSW, 2090. (1976: P1)

ROYLE, Harold George, MB BS *Syd*, 161 Rusden St., Armidale, NSW, (1961)

RUNNEGAR, Bruce, DSc, PhD *Qld*, Department of Geology, University of New England, Armidale, NSW, 2351. (1970)

RUSSELL, Terence George, BSc *Vic NZ*, PhD *NE*, G.P.O. Box 3505, Sydney, NSW, 2001. (1978: P2)

SCHOLER, Harry Albert Theodore, ME, Unit 2, "Kardinia", 1 Elamang Ave., Kirribilli, NSW, 2061. (1960: P1)

SCOTT, Martin Edward, 4 Walker Ave., Edgecliff, NSW, 2027. (1977)

SELBY, Esmond John, Selby's Scientific Ltd., P.O Box 121, North Ryde, NSW, 2113. (1933)

*SHARP, Kenneth Raeburn, BSc, Snowy Mountains Engineering Corporation, P.O. Box 356, Cooma North, NSW, 2630. (1948)

SHAW, Stirling Edward, BSc *WA*, PhD *NE*, FGAA, School of Earth Sciences, Macquarie University, North Ryde, NSW, 2113. (1966: P1)

SHERWIN, Lawrence, BSc *Syd*, Mining Museum, 36 George St., Sydney, NSW, 2000. (1967)

SIMS, Kenneth Patrick, BSc, 25 Fitzpatrick Ave., French's Forest, NSW, 2086. (1950: P20)

SMITH, Valerie D., BSc, P.O. Box 304, Raymond Terrace, NSW, 3234. (1978)

SMITH, William Eric, MSc *Syd and Oxf*, PhD *NSW*, MinstP, MAIP, Dept. of Applied Mathematics, University of N.S.W., Kensington, NSW, 2033; p.r. 24 Banks Ave., Turramurra, NSW, 2074. (1963: P3; Pres.1970)

SMITH-WHITE, William Broderick, MA, 37 Oliver Rd., Roseville, NSW, 2069. (1947: P4; Pres.1962)

STAER, Ronald Robert, FRAS, 33 Wallis St., Lawson, NSW, 2783. (1971)

STANTON, Richard Limon, MSc PhD *Syd*, FAA, Professor of Geology, University of New England, Armidale, NSW, 2351. (1949: P2)

STAPLETON, Emeritus Professor Thomas, MA DM BC *Oxf*, DCH (RCP&S), FRCP, FRACP, c/- Institute of Child Health, Royal Alexandra Hospital for Children, Camperdown, NSW, 2050. (1979)

STEPHENS, Frederick Selwyn, BSc PhD *NSW*, School of Chemistry, Macquarie University, North Ryde, NSW, 2113. (1975)

STRUSZ, Desmond Leslie, BSc PhD *Syd*, Bureau of Mineral Resources, G.P.O. Box 378, Canberra, ACT, 2606. (1951: P3)

STUBBS-RACE, Michael Anthony, 35 Dress Circle Rd., Avalon, N.S.W., 2107. (1976)

STUNTZ, John, BSc, 11 Jackson Crescent, Pennant Hills, NSW, 2120. (1951)

SUTERS, Ralph William, BSc *NSW*, 49 Walang Ave., Figtree, NSW, 2525. (1968)

SUTHERLAND, Frederick Linstead, BSc MSc *Tas*, PhD *James Cook*, The Australian Museum, 6-8 College St., Sydney, NSW, 2000. (1977)

SWAINE, Dalway John, PhD, FRACI, 29 Trentino Rd., Turramurra, NSW, 2074. (1973: P1; Pres.1976)

SWANSON, Thomas Baikie, CBE, MSc, 4/112 Walsh St., South Yarra, Vic, 3141. (1941: P2)

SWINBOURNE, Ellice Simmons, BSc PhD *NSW*, ASTC, FRACI, Principal, Nepean College of Advanced Education, Kingswood, NSW, 2750; p.r. 30 Ellalong Rd., Cremorne, NSW, 2090. (1948)

TALENT, John Alfred, BA MSc PhD *Melb*, 46 Woodvale Rd., Epping, NSW, 2121. (1973)

TAYLOR, Nathaniel Wesley, MSc *Syd*, PhD *NE*, Dept. of Mathematics, University of New England, Armidale, NSW, 2351. (1961)

TAYLOR, Trevor, 25a Low St., Mount Kuring-gai, NSW, 2080. (1979)

THOMAS, Mervyn Charles, MB BS, 76 Welfare Ave., Beverly Hills, NSW, 2209. (1978)

THOMPSON, Philip Wayne, BSc, 3 Sullivan Crescent, Wanniassa, ACT, 2903. (1971)

THOMSON, David John, BSc, 13 Minimah St., Northbridge, NSW, 2065. (1956)

THOMSON, Vivian Endel, BSc, DipEd, MT, CP, P.O. Box 186, North Ryde, NSW, 2113. (1960)

THWAITE, Eric Graham, BSc, 8 Allars St., West Ryde, NSW, 2112. (1962)

TICHAUER, Erwin R., DSc (Tech), Research Professor of Biomechanics, Apt. 12J, Kips Bay Plaza, 330 East 33rd St., New York, 10016, U.S.A. (1960)

TOMPKINS, Denis Keith, MSc PhD *Syd*, 3 Cawarra Place, Gordon, NSW, 2072. (1954: P1)

TYRRELL, William Trevor, 328 Pacific Highway, Crows Nest, NSW, 2065. (1973)

VAGG, Robert Sylvester, MSc *NSW*, PhD *Macq*, FRACI, School of Chemistry, Macquarie University, North Ryde, NSW, 2113. (1973: P2; Pres.1983)

VAGG, William James, BSc PhD, FRACI, CSR Energy Division, G.P.O. Box 483, Sydney, NSW, 2001; p.r. 9/15 Billyard Ave., Elizabeth Bay, NSW, 2011. (1973)

VALLANCE, Thomas George, BSc PhD, FGS, Dept. of Geology and Geophysics, University of Sydney, NSW, 2006. (1949: P4)

VAN DER POORTEN, Alfred Jacobus, BSc PhD BA MBA *NSW*, Professor of Mathematics and Head of the School of Mathematics and Physics, Macquarie University, North Ryde, NSW, 2113. (1971: P2)

VEEVERS, John James, MSc *Syd*, PhD *Lond*, DIC, School of Earth Sciences, Macquarie University, North Ryde, NSW, 2113. (1953)

VERNON, Ronald Holden, MSc *NE*, PhD *Syd*, School of Earth Sciences, Macquarie University, North Ryde, NSW, 2113. (1958: P2)

*VOISEY, Emeritus Professor Alan Heywood, DSc *Syd*, 9 Milton St., Carlingford, NSW, 2118. (1933: P13; Pres.1966)

VOLMERSHAUSEN, Wolf, 34 The Crescent, Homebush, NSW, 2140. (1981)

WAKEFIELD, Denis, MB BS *NSW*, FRACP, FRCPA, School of Pathology, University of N.S.W., Kensington, NSW, 2033. (1984)

WALLACE, Harry Lachlan, BE, 25 York St., Beecroft, NSW, 2119. (1976)

WARD, Colin Rex, BSc, PhD *NSW*, AMAusIMM, School of Applied Geology, University of N.S.W., Kensington, NSW, 2033. (1968: P1)

WARD, Judith, BSc, 16 Mortimer Ave., New Town, Tas, 7008. (1948: P2)

WARD, Professor John Manning, AO, MA, LLB, AAHA, FASSA, FRAHS, Vice-Chancellor and Principal, University of Sydney, NSW, 2006. (1983: P1)

WARD, Norman James, 19/41 Milray Ave., Wollstonecraft, NSW, 2065. (1975)

WARDEN, Darrell Ewan, 40 Chester Ave., Baulkham Hills, NSW, 2153. (1982)

WARREN, Bruce Albert, MB BS BSc(Med) *Syd*, MA DPhil DSc *Oxf*, FRCPA , FRCPath, Professor of Pathology, University of N.S.W., Kensington, NSW, 2033; p.r. 8 Arcadia St., Coogee, NSW, 2034. (1974: P1; Pres.1981)

WASS, Robin Edgar, BSc *Qld*, PhD *Syd*, FGS, Dept. of Geology and Geophysics, University of Sydney, NSW, 2006. (1965: P1)

WEBBY, Barry Deane, MSc *NZ*, PhD DSc *Bristol*, FGS, Dept. of Geology and Geophysics, University of Sydney, NSW, 2006. (1966: P1)

WELCH, John Alister, MSE, Dip ASTC (Mech.Eng.), MIE Aust, 8 Terrigal Ave., Turramurra, NSW, 2074. (1980)

WEST, Norman William, BSc, 40 Brightlands Ave., Blackheath, NSW, 2785. (1954)

WESTHEIMER, Gerald, BSc *Syd*, PhD, FSTC, Professor of Physiology, University of California, 2575, Life Sciences Building, Berkeley, California, 94720, U.S.A. (1949)

WHITLEY, Alice, MBE, PhD, 39 Belmore Rd., Burwood, NSW, 2134. (1951)

WHITTAKER, Vivian Kenneth Leslie, MB BS *Qld*, PhD *ANU*, 3/20 Musgrave St., Mosman, NSW, 2088. (1980)

WILKINSON, John Frederick George, BSc *Qld*, PhD *Camb*, FMSA, Professor of Geology, University of New England, Armidale, NSW, 2351. (1961: P2)

WILLIAMS, Peter Allan, BA PhD *Macq*, Dept. of Chemistry, University College, P.O. 78, Cardiff, CF1 1XL, Wales. (1981: P1)

WILLIS, Ian Lehane, BA Hons, MAIG, Geological Survey of N.S.W., c/- Dept. of Geology, University of New England, Armidale, NSW, 2351. (1982: P2)

WILSON, Ian Robert, BA *Macq*, c/- N.S.W. Dept. of Main Roads, P.O. Box 680, Broken Hill, NSW, 2880. (1977)

WILSON, Mark Hume, BA DipEd, 10 Neil St., Epping, NSW, 2121. (1976)

WINCH, Denis Edwin, MSc PhD *Syd*, FRAS, Dept. of Applied Mathematics, University of Sydney, NSW, 2006. (1968)

WRIGHT, Anthony James, BSc PhD *Syd*, Dept. of Geology, Wollongong University, NSW, 2500. (1961)

WRIGHT, Norbert Thomas, BDS *Syd*, FICD, Chief Dental Officer, N.S.W. Dept. of Health; p.r. 3 Narena Close, Beecroft, NSW, 2119. (1975)

WYLIE, Russell George, MSc PhD, FAIP, FInstP, National Measurement Laboratory, P.O. Box 218, Lindfield, NSW, 2070. (1960)

YATES, Daniel Alan, JP, 6/22 Queenscliff Rd., Queenscliff, NSW, 2096. (1977)

YOUNG, Cynthia Glynn, P.O. Box 245, Strathfield, NSW, 2135. (1971`

ASSOCIATES

BALAREZO, Oscar Walter Mendoza, 26 Phillips St., Neutral Bay, NSW, 2080. (1976)

BLACK, Lesley, 193 Iodide St., Broken Hill, NSW, 2880. (1975)

BROCK, Peter John, 19 Brotherton St., Merrylands, NSW, 2160. (1983)

CAMERON, Stewart Blakeway, 101 Adelaide Parade, Woollahra, NSW, 2025. (1980)

CORNWELL, Richard Kenneth, 79 Boundary St., Roseville, NSW, 2069. (1980)

EWING, Graeme Paul, 1 Apollo Ave., West Pymble, NSW, 2073. (1980)

FERRERO, Edward, (1975)

GOVETT, Marjorie H., BA MA, 12A Torrens St., Blakehurst, NSW, 2033. (1980)

GRAY, Anne Christine, 24 Handley Ave., Thornleigh, NSW, 2120. (1980)

HARVEY, Steven Kenneth, 119 Wattle Rd., Jannali, NSW, 2226. (1978)

HONSON, Vanessa Jeanie, 158 Alma Rd., Padstow, NSW, 2211. (1980)

JOASS, Gregory George, 49 Coombe St., Collie, WA, 6225. (1975)

KEMENY, Anna Ruth (Mrs.), 21 Westmeath Ave., Killarney Heights, NSW, 2087. (1975)

KING, Thelma (Mrs.), 20 Beaumont Rd., Killara, NSW, 2071. (1974)

LABUTIS, Susan Marilyn, BA, (Mrs.), 10 Ethel St., Hornsby, NSW, 2077. (1981)

LE FEVRE, Catherine Gunn, DSc *Lond*, 6 Aubrey Rd., Northbridge, NSW, 2063. (1961)

NAPPER, Gillian Margaret, BA DipEd, LTCL, (Mrs.), 32 Marjorie St., Roseville, NSW, 2069. (1980)

PAYNE, Paul Wilfrid, 2 Selwyn Close, Pennant Hills, NSW, 2120. (1980)

PENTECOST, Fred Edward, 51 Miowera Rd., North Turramurra, NSW, 2074. (1975)

RILEY, Beatrice Elizabeth, BA Hons, (Mrs.), 19 Kent Rd., North Ryde, NSW, 2113. (1973)

SCHÖN, Richard Willem, BSc Hons, 80 Moss St., West Ryde, NSW, 2114. (1977)

SMITH, Steven Jeremy, 65 Fairlawn Ave., Turramurra, NSW, 2074. (1980)

STANTON, Alison Amalie, BA, (Mrs.), 35 Faulkner St., Armidale, NSW, 2350. (1961)

STUBBS-RACE, Martin Laurence, 35 Dress Circle Rd., Avalon, NSW, 2107. (1978)

SWAINE, Winifred Christian Hendry, (Mrs.), 29 Trentino Rd., Turramurra, NSW, 2074. (1973)

SYMON, Julian, 17 Crawford Rd., Lower Templestowe, Vic, 3107. (1975)

TILL, Vaughan Scott, BSc Hons *Syd*, 12 Appletree Drive, NSW, 2120. (1978)

WARREN, Diana Mary, (Mrs.), 8 Arcadia St., Coogee, NSW, 2034. (1981)

YATES, Jennifer Aileen, 6/22 Queenscliff Rd., Queenscliff, NSW, 2096. (1977)

Index to Volume 117

JOURNAL AND PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES

VOLUME 117

PARTS 1-4 (Nos. 331-334)

1984

ISSN 0035-9173

PUBLISHED BY THE SOCIETY
PO BOX N112, GROSVENOR STREET, NSW 2000

Royal Society of New South Wales

OFFICERS FOR 1984-1985

Patrons

HIS EXCELLENCY THE RIGHT HONOURABLE SIR NINIAN STEPHEN,
A.K., G.C.M.G., G.C.V.O., K.B.E., K.St.J., GOVERNOR-GENERAL OF AUSTRALIA

HIS EXCELLENCY AIR MARSHALL SIR JAMES ROWLAND, K.B.E., D.F.C., A.F.C.,
GOVERNOR OF NEW SOUTH WALES.

President

R. S. BHATHAL, B.Sc., Ph.D.

Vice-Presidents

R. S. VAGG
T. W. COLE
R. L. STANTON
B. A. WARREN
W. H. ROBERTSON

Honorary Secretaries

D. S. KING
M. KRYSKO v. TRYST

Honorary Treasurer

A. A. DAY

Honorary Librarian

F. L. SUTHERLAND

Members of Council

P. J. DERRICK
H. S. HANCOCK
J. H. LOXTON
R. M. MacLEOD
R. H. READ
M. A. STUBBS-RACE
W. J. VAGG
D. E. WINCH

New England Representative: S. C. HAYDON

CONTENTS

Parts 1 and 2

Parts 3 and 4

Dates of publication:
Parts 1 and 2: August 6, 1984
Parts 3 and 4: December 30, 1984

NOTICE TO AUTHORS

A "Style Guide to Authors" is available from the Honorary Secretary, Royal Society of New South Wales, PO Box N112, Grosvenor Street, NSW 2000, and intending authors *must* read the guide before preparing their manuscript for review. The more important requirements are summarized below.

GENERAL

Manuscripts should be addressed to the Honorary Secretary (address given above).

Manuscripts submitted by a non-member must be communicated by a member of the Society.

Each manuscript will be scrutinised by the Publications Committee before being sent to an independent referee who will advise the Council of the Society on the acceptability of the paper. In the event of rejection, manuscripts may be sent to two other referees.

Papers, other than those specially invited by Council, will only be considered if the content is substantially new material which has not been published previously, has not been submitted concurrently elsewhere, nor is likely to be published substantially in the same form elsewhere. Well-known work and experimental procedure should be referred to only briefly, and extensive reviews and historical surveys should, as a rule, be avoided. Letters to the Editor and short notes may also be submitted for publication.

Original papers or illustrations published in the Journal and Proceedings of the Society may be reproduced only with the permission of the author and of the Council of the Society; the usual acknowledgements must be made.

PRESENTATION OF INITIAL MANUSCRIPT FOR REVIEW

Typescripts should be submitted on bond A4 paper. A second copy of both text and illustrations is required for office use. Manuscripts, including the abstract, captions for illustrations and tables, acknowledgments and references should be typed in double spacing on one side of the paper only.

Manuscripts should be arranged in the following order: title; name(s) of author(s); abstract; introduction; main text; conclusions and/or summary; acknowledgments; appendices; references; name of Institution/Organisation where work carried out/or private address as applicable. A table of contents should also accompany the paper for the guidance of the Editor.

Spelling follows "The Concise Oxford Dictionary".

The Systeme International d'Unites (SI) is to be used, with the abbreviations and symbols set out in Australian Standard AS1000.

All stratigraphic names must conform with the International Stratigraphic Guide and must first be cleared with the Central Register of Australian Stratigraphic Names, Bureau of Mineral Resources, Geology and Geophysics, Canberra.

Abstract. A brief but fully informative abstract must be provided.

Tables should be adjusted for size to fit the format paper of the final publication. Units of measurement should always be indicated in the headings of the columns or rows to which they apply. Tables should be numbered (serially) with Arabic numerals and must have a caption.

Illustrations. When submitting a paper for review all illustrations should be in the form and size intended for insertion in the master manuscript. If this is not readily possible then an indication of the required reduction (such as reduce to ½ size) must be clearly stated.

Note: There is a reduction of 30% from the master manuscript to the printed page in the journal.

Maps, diagrams and graphs should generally not be larger than a single page. However, larger figures can be printed across two opposite pages.

Drawings should be made in black Indian ink on white drawing paper, tracing cloth or light-blue lined graph paper. All lines and hatching or stripping should be even and sufficiently thick to allow appropriate reduction without loss of detail. The scale of maps or diagrams must be given in bar form.

Half-tone illustrations (photographs) should be included only when essential and should be presented on glossy paper.

Diagrams, graphs, maps and photographs must be numbered consecutively with Arabic numerals in a single sequence and each must have a caption.

References are to be cited in the text by giving the author's name and year of publication. References in the reference list should follow the preferred method of quoting references to books, periodicals, reports and theses, etc., and be listed alphabetically by author and then chronologically by date.

Abbreviations of titles of periodicals shall be in accordance with the International Standard Organization IS04 "International Code for the Abbreviation of Titles of Periodicals" and International Standard Organization IS0833 "International List of Periodical Title Word Abbreviations" and as amended.

MASTER MANUSCRIPT FOR PRINTING

The Journal is printed by offset using pre-typed pages. When a paper has been accepted for publication the author will be supplied with a set of special format paper. The text may either be typed by electric typewriter directly on to the format paper or a word processor print-out assembled on it. Details of the requirements for text production will be supplied with the format paper.

Reprints. An author who is a member of the Society will receive a number of reprints of his paper free. An author who is not a member of the Society may purchase reprints.

Contents

VOLUME 117, PARTS 3 and 4

Diamond Press, 66 O'Riordan St, Alexandria, Sydney.